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THE UNIVERSITY OF ALBERTA

SOME ASPECTS OF INDUSTRIAL MAPPING

by

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A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE
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THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled "Some Aspects of Industrial Mapping" submitted by Shook-Fah Chong in partial fulfillment of the requirements for the degree of Master of Science.

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ABSTRACT

This thesis presents conclusions resulting from a comparative evaluation of different cartographic techniques for presenting manufacturing industry data. All the important basic problems such as map projection, map scale, selection and generalization of data, symbolization of data and application of cartographic methods are investigated as they affect the design of manufacturing maps.

In the Province of Alberta, information concerning manufacturing industry in each census division and in the main centers (with population 2,500 or over) is of great range within each category of data. In addition, the characteristics of the various categories of data are quite different. Various methods suitable for portraying these various kinds of manufacturing data, such as repeated geometrical symbols, bar graphs, proportional circles, three-dimensional cubes, and the choropleth method are discussed.

Finally, a collection of maps showing manufacturing in Alberta has been compiled from the statistics supplied by the Alberta Bureau of Statistics. These sample illustrations are used as a basis for analyzing the advantages and disadvantages of different cartographic methods, relative to specific categories of data. The particular types of method most suitable for certain data categories are

summarized. Those sample maps which employ the methods found to be most suitable should provide a pleasing visual impression, and should give the map reader a quick understanding of the information being portrayed.

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CHAPTER I

INTRODUCTION

As human society develops, men need to understand more thoroughly the world surrounding them. Maps can show the spatial distributions and relationships of physical, social and economic phenomena on the earth's surface. Therefore, a map may act as a vehicle to assist the process of communication.

This study is concerned with the mapping of a particular type of economic activity, manufacturing industries. For illustrative purposes, the Province of Alberta will be considered as the case study area in this thesis. The distribution of manufacturing is a matter of great importance to individual towns throughout Alberta, since the government is encouraging a policy of industrial dispersion in an attempt to spread growth throughout the province. In this context effective industrial mapping, which provides a record of the present manufacturing geography of the province as a basis for future planning can be a useful aid to economists, geographers, administrators, and planners in Alberta and elsewhere. In fact, the Alberta Bureau of Statistics and economic geographers in the Department of Geography have expressed an interest in the mapping of these data. Unfortunately there are few detailed industrial maps being compiled in Alberta, because companies are loath to give to researchers any information which might be of use to competitors, and probably because of the confidential nature of much data on manufacturing companies, which the Alberta Bureau of Statistics cannot reveal under 'The Statistics Bureau Act.' According to this act,

> No report, summary of statistics or other publication issued under this Act shall contain any of the particulars contained in any individual return so arranged as to enable any person to identify any particulars so published as being particulars relating to any individual person or business except when the previous consent in writing of the individual person or of the person in authority in the business has been obtained for the release of the information.[1]

At the same time, no single criterion or group of criteria can yield a map of the geography of all manufacturing activity. Individual aspects have to be mapped individually to build up an adequate cartographic portrayal of industry. This can be accomplished, however, only if data in sufficient detail are available.

There is a range of possible variables which can be presented in industrial mapping, such as types of plants, location, size of site, value of capital equipment, value of output, number of persons employed, wages and so on. However, these variables cannot all be included in a single map of manufacturing industry, since they are unequal in importance and are valid for different purposes. Only variables which are essential and pertinent to the subject matter under consideration should be brought into focus.

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[1] Revised Statutes of Alberta 1970, Vol. 6, Chapter 350, 1970, p. 5264, Edmonton: Queen's Printer.

Since the study proposed here concerns the mapping of manufacturing industry, the variables selected will be those basic elements of manufacturing which are of practical interest to the industrial geographer, and those which will portray as far as possible all aspects of the manufacturing industry to the reader. Of course, these attempts will be limited by the inability to obtain complete information.

In discussions with staff of the Alberta Bureau of Statistics, it was established that it would be possible within the constraints of data availability to map manufacturing types, total number of employees, total value added, total value of manufacturing shipments, and total salaries and wages paid in manufacturing. To produce a basis for comparative cartographic analysis, a series of maps of manufacturing industries in Alberta have been compiled from the point of view of use by the industrial geographers, economists, and others.

The advantage of graphic presentation of the statistical data is that it is far more appealing visually than a mass of inert figures. Statistics which can be obtained from a map are normally less exact than those found in tables; however, a basic assumption of mapping is that cartographic presentation can compress the original data into an immediately comprehensible form. From such a comprehensive picture important spatial relationships such as magnitude and location of economic activities can be readily and simultaneously appraised, thus facilitating interpretation and analysis of manufacturing in Alberta.

The main task of this thesis will be the comparative evaluation of different cartographic techniques in presenting industrial data. The various graphic forms of maps such as geometrical symbols, bar graphs, proportional circles, pie graphs, divided rectangles, cube symbols and choropleth method are used for the manufacturing data.

I. Organization and Procedure

For this thesis, all the statistical data on manufacturing have been obtained from the Alberta Bureau of Statistics. These data are mainly based on census divisions. For more intensive study, detailed industrial maps of the main centers with a population of 2,500 and over in each census division are compiled.

The thesis is divided into five chapters. The first chapter is the introduction. The second chapter is concerned with the important basic problems in manufacturing cartography, such as application of cartographic methods, map projection, map scale, the selection and generalization of data, and symbolization of data. As they are integral parts in designing industrial maps, their discussion is relevant.

The third chapter discusses the cartographic methods used for manufacturing maps, such as repeated symbols, line graphs, bar graphs, logarithmic graphs, pie graphs, divided rectangles, three-dimensional cubes and choropleth. These methods are analyzed, emphasizing their suitability and application in the representation of statistical manufacturing data.

The fourth chapter discusses the advantages and disadvantages of the illustrations of different cartographic solutions. Some manufacturing maps of Alberta are compiled to provide the illustrative examples.

Chapter five includes both summary and conclusions.

II. Literature Review

In the English literature on industrial mapping, there are three main sources of information which are pertinent to this thesis. These are: (1) papers which discuss specific examples of industrial mapping; (2) papers concerned mainly with measuring those characteristics of manufacturing dealing with mapping techniques; and (3) atlases which include maps portraying industrial information. Each of these three main sources is reviewed below.

A. Studies of Industrial Mapping

Previous studies which are specifically involved with the application of cartographic techniques to manufacturing statistics are few, and generalizations are, therefore, difficult to make. However, there are three studies which have made important contributions in this area. These are MacGregor's (1967) work on the mapping of industry, Lonsdale and Thompson's (1960) map of Soviet manufacturing, and Thompson and Miyazaki's (1959) map of Japanese manufacturing.

1. Purpose of Studies

MacGregor feels that although industry is important to present society, the value of existing mapping is limited since the nature of the information shown is simple and generally presented at only a small scale. He proposes a method of producing industrial maps which has a scientific and practical value in planning.

Manufacturing industry holds an important place in the Soviet economy, but the only detailed manufacturing maps available are for the distribution of manfacturing in 1939. Newer maps usually are at a small scale, showing the general location of selected types of industrial activity, and providing only a vague indication of the relative magnitudes of manufacturing in the various industrial regions and urban centers, Lonsdale and Thompson's study presents a map showing the relative importance of manufacturing in the 571 leading industrial centers of the Soviet Union in order to try to overcome these deficiencies.

Japan has been the leading industrial nation of Asia since the second world war. The distribution of manufacturing and of the factors that have led to this manufacturing pattern are of concern to anyone interested in Japan's economy. Therefore, Thompson and Miyazaki argue that an accurate and detailed postrecovery map of Japan's manufacturing is a worthwhile and timely addition to the source material.

2. Techniques

MacGregor used a six-armed star stymbol with a circle at the center of the star, to present any six variables of a plant, such as type of plant, location, ground area, capital value, output value, number of persons employed, age of formation, number of male and female employees, and so on. Different quantitative scales can be used along the various radials of a star. The circle at the centre of the star would be of a constant size to impress shape differences between stars, and it would contain either a letter denoting the type of industry carried on or a key number referring to the name of the proprietary company or firm. This method was based on data from individual firms with large-scale production.

As the data for Soviet industrial centers were unavailable, estimation procedures had to be used to determine the relative importance of industrial centers. Lonsdale and Thompson first used the number of workers and amount of fixed capital to determine the magnitudes of manufacturing in 23 regional divisions of the country and established the mean of the magnitudes of manufacturing. They then estimated the magnitudes of manufacturing at individual centers and used proportional symbols to illustrate the relative importance of manufacturing industry for the various centers.

Thompson and Miyazaki used only one dot map portraying information on manufacturing workers in 1954 to exhibit the distribution patterns of Japan's manufacturing. As obtaining statistical material in sufficient spatial detail to assure accurate placement of dots was a major problem, statistics were chosen from a number of different sources. Each dot was used to represent 100 manufacturing workers, and the dots were located where they belong in each community. Large-scale detailed maps were used to facilitate the process.

The manufacturing industry in Japan is unevenly distributed. It is mainly concentrated in the six largest cities near the sea; that is, Tokyo, Osaka, Nagoya, Kyoto, Yokohama and Kobe. In these six cities, the manufacturing areas are so concentrated that cluster dots result. By contrast, in the towns and villages, manufacturing workers are so sparsely distributed that one dot was used to represent several villages when employment in each was small, or one dot was used if an isolated village or town had approximately 100 employees.

The dot symbol is not suitable for portraying such information if a more accurate estimate of the figures involved is required by the map reader.

3. Conclusions

Little research has been done on industrial mapping, and usually only a single method has been used in the literature. It is obvious that manufacturing industries should be represented by more than one variable. MacGregor, who realized this, tried to use a star symbol to present six variables of a plant, but the problem of obtaining the information is illustrated by the fact that MacGregor could complete cartographic presentation of industry for only two of the five towns in central Scotland: Alloa and Grangemouth. The method which MacGregor uses was based on individual firms with large-scale mapping, but in practice, it is almost impossible to gather all the necessary information for large-scale mapping from individual firms.

Proportional circles are the best means for comparing the magnitudes of manufacturing, since the various sizes of the circles can give a quick impression to the reader of the relative importance of areas within the distribution. The use of proportional circles in Lonsdale and Thompson's study to indicate the relative importance of industrial centers in the Soviet Union is successful.

The dot symbol is theoretically best for showing distribution patterns and for portraying actual values of the variable involved. But in Thompson and Miyazaki's work on Japan's manufacturing, the employees are so unevenly distributed that in the six largest cities the dots merge together forming dark patches. The legibility of the individual dot becomes obscured. This is because of the exceptionally large number of manufacturing employees in these cities relative to the small value represented by each dot, so that a large number of dots results. In these congested areas, the map reader can hardly comprehend accurately the number of manufacturing employees present.

On the other hand, in village or town areas with a small population of employees, the map may give only a vague impression of distribution, if one dot has to be used to represent several villages. If an isolated village has slightly more or fewer than the unit number of employees, that village will be represented by one dot; however, this is not a very accurate solution, since the map reader cannot judge how much (or even in what direction) the employee population differs from the unit number. For areas like Japan, therefore, the dot symbol is not as effective as one might expect it to be.

On the whole, if only one map with a single method is used for an entire study, it is inadequate to show a comprehensive picture of manufacturing. More variables and different methods should be applied to present these statistics.

B. Studies on Measurement of Manufacturing Characteristics

There are numerous geographic studies which have dealt with the measurement of manufacturing in an attempt to discover which criterion can best portray manufacturing data in map form. The methods available are very diverse. Some maps are based on a single criterion, while others employ a combination of two or more criteria, especially by means of ratios whereby one absolute value is compared to another. It is difficult to assess in general terms which method is the most effective, as the results may vary considerably when different criteria are being employed. The choice of criteria, of course, depends on the purpose of the individual study.

The papers reviewed here are those dealing both with the measurement of the characteristics of manufacturing, and with mapping technique. These articles include Thompson's (1955) work on a method for measuring manufacturing; Alexander and Lindberg's (1961) measurements of manufacturing utilizing coefficients of correlation; Morris and Heller's (1969) work on the measurement of manufacturing in the industrialized area of Argentina and New South Wales; and Wong's (1968) correlation analysis of criteria for the measurement of manufacturing in Melbourne, Australia.

1. Purpose of Studies

Thompson considers single-criterion measurement to be inadequate for the spatial comparison of industries between or within areas. He suggests the use of several criteria to provide a more comprehensive and widely applicable method of measurement. He presents a method for the measurement of two aspects of manufacturing, magnitude and intensity. Magnitude is used here to mean quantity of manufacturing, and intensity refers to the importance of manufacturing in the economy of leading standard metropolitan areas in the United States.

Alexander and Lindberg, whose research is based on the United States, attempt to investigate the difference between criteria for measuring manufacturing activity, as these criteria differ from place to place. The assumption has been made that if different criteria are in fact equally useful for showing the variation in manufacturing from one location to another, the long debate on what criterion is best for portraying variation in manufacturing is unnecessary.

Morris and Heller think that for countries where modern manufacturing is not too well developed, relationships between various characteristics of manufacturing activity will be quite different from those found in the

North American situation. The same type of correlation procedure as used for the United States by Alexander and Lindberg was applied to Argentina and New South Wales. The result was a lower level of correlation between characteristics of manufacturing activity, thus indicating a lower degree of similarity between the characteristics used. This re-opens the question of the most suitable criteria for mapping manufacturing activity.

In order to save time wasted by unnecessary duplication, yet at the same time to show all the possible spatial variations in manufacturing, Wong suggests using the coefficient of correlation as the criterion for determining important aspects of manufacturing activity. His research is based on the Melbourne Metropolitan Area.

2. Methods

Thompson used five criteria (total employed in manufacturing, value added by manufacturing, salaries and wages, total employed in all industry groups, and total population) for the measurement of manufacturing magnitude and intensity.[2]

Magnitude, used to mean quantity of manufacturing, is calculated from three criteria: (1) all employees in manufacturing, (2) salaries and wages, and (3) value added by manufacturing. Separate ratings are calculated for these three criteria of magnitude and are then averaged to secure a multiple criteria rating.

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[2] For further detailed calculation see Thompson (1955) pp. 418-433.

Intensity refers to the importance of manufacturing in the economy of leading standard metropolitan areas in the United States, and is calculated from three criteria: (1) the ratio of all employees in manufacturing to the total employed in all industry groups, (2) the ratio of all employees in manufacturing to the total population, and (3) the ratio of value added by manufacturing to the total population (value added per person).

Ten classes of both magnitude and intensity are established to classify 53 leading standard metropolitan areas in the United States. These multiple - criteria ratings of magnitude and intensity are transferred onto two maps. Proportional circles are used on these maps to represent magnitude, and the pattern within the circle indicates the intensity.

Alexander and Lindberg use a different method in their study of United States manufacturing. They use correlation analysis to compute coefficients of correlation between thirteen criteria of manufacturing characteristics varied from place to place within the United States. The result indicates that there are great similarities among various measures of manufacturing available at the county level. Therefore, they conclude that mapping any one of the characteristics of manufacturing will give an equally valid indication of the nature of manufacturing activity.

As noted above, the same type of correlation procedure as used for the United States was applied to Argentina and New South Wales by Morris and Heller, the result indicated low levels of correlation. Therefore they conclude that the degree of correlation between manufacturing characteristics varies from place to place. Crude and weighted residual and ratio maps are used to illustrate in this article.

Another attempt is made by Wong, using correlation analysis to assess the criteria which would be useful in measuring spatial variations in manufacturing in Melbourne. His analysis show that the original eight criteria fall into two groups. Group I consists of persons employed, value of wages and salaries paid, value of production, capital expenditure, and number of factories with over 100 workers each. Group II consists of total number of factories, number of factories with 21-100 workers each, and number of factories with less than 20 workers each. Criteria within each group are of high correlation, but criteria between the two groups are of low correlation. Hence Wong advises that only one criterion from each of the groups is needed to plot the picture of manufacturing activity. In his study, only one map is compiled. He uses the same size of proportional circles but with two different value scales to show the high correlation between manufacturing information on persons employed and value of production.

3. Conclusions

There had been a long-standing dispute over which criteria can best portray manufacturing data in map form. Various types of measurement have been applied but no firm conclusions have been reached. There are so many differences between the kinds of statistics available, and the stage and areal spread of manufacturing development varies so greatly, that it is hard to generalize and find one method which is always appropriate.

The decision about which criteria to use must be based on the purpose of individual studies. For those interested in certain aspects of manufacturing such as value added or number of employees, single-criterion measurement will be adequate.

From the cartographic point of view, the most efficient way which can show the information clearly to the map user is to have each map portray only one type of information. When several kinds of information are portrayed in the same map, the time spent referring to the legend is increased. Therefore for showing a comprehensive picture of the manufacturing industry, a series of maps must be compiled.

C. Atlases Portraying Information on Manufacturing Industry

Almost every economic atlas is concerned with manufacturing mapping. It should be stated that this review is limited to Canadian atlases and does not include all atlases dealing with manufacturing. Since the cartographic treatments in these Canadian provincial atlases vary somewhat, a review of each one will give a sufficient idea of how experienced cartographers translate manufacturing data into graphic form.

Besides The National Atlas of Canada, only the following provinces in Canada produced provincial atlases: British Columbia Atlas of Resources (1956), Atlas of Alberta (1969), Atlas of Saskatchewan (1969), Economic Atlas of Manitoba (1960), Economic Atlas of Ontario (1969), and Atlas de Québec (1969).

In these atlases, the manufacturing section is of varying proportions. British Columbia Atlas of Resources contains 5 maps, Atlas of Alberta 32 maps, Atlas of Saskatchewan 10 maps, Economic Atlas of Ontario 58 maps and Atlas de Québec 23 maps. In the National Atlas of Canada, manufacturing data are compiled in tables and graphs, with no mapping.

1. Contents

There are some other variations between the contents of the atlases mentioned above. For example, Atlas de Québec is only concerned about the number of employees in each type of manufacturing industry. On the other hand a more comprehensive picture of manufacturing industry can be obtained from the Economic Atlas of Ontario and Atlas of Alberta.

In the Economic Atlas of Ontario, the maps involved in the manufacturing section are: growth of manufacturing employment by county 1871-1961, general characteristics of manufacturing in urban centres, changes in manufacturing characteristics, dominant major manufacturing groups, location quotient of manufacturing 1965, refined index of manufacturing diversity 1965, index of manufacturing plant dominance 1965, location of new plants, location quotients on manufacturing employment, and wage structure 1957-1961.

In this atlas, a wide range of cartographic design techniques have been applied. The numerous general characteristics of manufacturing are shown dynamically. For example, the map showing degree of specialization of industrial centres gives the reader a particularly clear picture of the manufacturing economy of Ontario. Further, L.J. Harris remarks that:

> This atlas is encouraging both to geography and cartography. The essence of geography is the study of the interaction between the environment and man. The satisfactory presentation of the statistics of this interaction in an atlas requires a thorough knowledge of cartography. At the same time, such an atlas helps to identify geography, to strengthen its core, and to demonstrate the interdependence of geography and cartography.[3]

In the Atlas of Alberta manufacturing maps include the growth of manufacturing, net value of production, gross value of production and types of manufacturing industry. J.S. Keates remarks:

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[3] L.J. Harris, 'Economic Atlas of Ontario -- Cartographical Survey,' Geographical Journal, Vol. 136, part 3, Sept. 1970, p. 486.

> From this assembly of basic information, a real picture can be obtained of the distribution, kind, size and trend of industry in the province.[4]

2. Techniques

Various types of cartographic methods have been applied in these manufacturing maps, such as geometrical symbols (dot, square, triangle, and so on), proportional circles, pie graphs, choropleth, bar graphs and flow diagram (see table 1).

In Atlas de Quebéc, a large selection of proportional geometrical symbols (diagram) is used to portray the number of employees in different branches of manufacturing industry; for example: square, rectangle, triangle, trapezius, pentagon, hexagon, diamond, oval, half-oval, circle and half-circle.

In the Atlas of Alberta, different methods are combined in the same map; for example, the choropleth method was used to show the percentage increase in gross value and net value, with superimposed bar graphs for gross and net value. Quarter-circles are applied in the map to show the breakdown in distribution of gross value for administrative units for the years 1920, 1935 and 1965.

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[4] J.S. Keates, 'Atlas of Alberta--Reviews,' *The Cartographic Journal*, Vol. 7, No. 1, 1970, p. 55.

In the Economic Atlas of Ontario, especially noteworthy are the use of new (particularly mathematical) methods of economic geographical analysis of the structure and distribution of the economy, the bold use of maps of synthesis, and concern for the representation of the dynamic interraction between the various aspects of manufacturing.

3. Conclusions

The primary function of a map is the presentation of information, but it has in addition a responsibility of conveying this information in a legible and pleasing form. Therefore, various techniques are being applied to the statistics to convey a more pleasing effect. And the addition of colour can present to the cartographer much broader scope for symbolization and to give the reader an aesthetically-pleasing finished product. The advantage of using a variety of colours and cartographic methods becomes obvious when one studies the manufacturing sections of the above-mentioned atlases, all of which (except the Atlas de Quebec) are in colour.

In this thesis, different types of cartographic methods are applied to the available manufacturing statistics. The mathematical method used in the Economic Atlas of Ontario for measuring manufacturing statistics, such as location quotient of manufacturing employment, is applied in map 21 of this thesis.

Table 1. Different Types of Cartographic Methods Apply in Canadian Provincial Atlases

Cartographic Methods / Atlases	Cartodiagram								Choropleth
	repeated geometrical symbol	bar graph or 3 dimensional bar	constant circle with pie graph	proportional circle with choropleth	proportional circle with pie graph	sphere	proportional geometrical symbol	flow Diagram	
The National Atlas of Canada	✓		✓						
British Columbia Atlas of Resources			✓			✓			✓
Atlas of Alberta	✓	✓			✓				✓
Atlas of Saskatchewan	✓			✓	✓				
Economic Atlas of Manitoba	✓				✓				
Economic Atlas of Ontario	✓	✓		✓	✓			✓	✓
Atlas de Quebéc							✓		

CHAPTER II

CARTOGRAPHIC METHOD AND MAP FUNCTION

I. The Application of Cartographic Method

A map functions as a form of communication and as an image of surface phenomena, and presents data spatially organized in two or three dimensions for visual inspection. The effectiveness of a map must be assessed by the choice of scale and projection, the selection and generalization of data, and the manner of symbolization. All these elements affect the content of the map.

E.L. Ullman said, "The map's basic contribution is to reduce reality to a scale which can be comprehended".[1] Therefore the employment of a projection and the use of scale reduction enables the cartographer to preserve certain aspects of the spatial relationships existing on the globe. The selection of data on the map provides a correlation between the map and that part of the earth's surface which it represents. The symbolization is used to qualify the subject and communicate the information to the reader.

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[1] E.L. Ullman, 'Human Geography and Area Research,' A.A.A.G., Vol. 43, 1953, p. 218.

It is most important that when statistics are presented cartographically, the resultant map should be capable of giving back to its user, after a minimum of inspection and effort, a clear indication of the information it was designed to carry and the main task it has to make. For industrial mapping the aim is to transfer the manufacturing statistics into graphic form to show, for example, the present graphic distribution and development of industry and indicate the productivity or importance of industrial centres. Therefore, the right choice of technique will aid the effectiveness of the map as a communication form.

II. Map Scale

The scale of a map is the ratio of distances measured in units on the map to distances measured in the same units on the ground. It is impossible to show phenomena on a map without using scale, since everything depicted on maps must be reduced in size to a varying degree according to the scale of the map.

Map scale is one of the most important cartographic elements. The choice of scale affects the cartographer's judgement in designing the layout of the maps, handling of data, choosing the size of the symbols and the values they represent. Thus the scale of a map is an important factor which affects the details of the phenomena to be shown. For example, using the repeated symbols on a large-scale map, there would be sufficient space for showing the distribution of phenomena in great detail, because the value which each symbol represents can be small and its size large. On the other hand, if we change the map to the smaller scale without adjusting the size and value of the symbols accordingly, the symbols will be crowded together. Therefore, an inappropriate relationship between map scale, size and value of symbols can cause misinterpretation on the part of the map reader.

No single map scale will satisfy all requirements. Therefore the scale must be chosen to suit the purpose of the map. The selection of a suitable scale is influenced mainly by the amount of detail required, size of format and size of area to be depicted. Generally speaking, the map scale should be large enough to give an immediate visual impression of the patterns of distribution. At the same time, it should not be so small that crowding of symbols would result in illegibility.

The importance of scale indication is self-evident, and ideally it should be indicated on a map in all three ways: as a representive fraction, in words, and graphically. At least the graphical scale should appear on each map, and it would be to the advantage of a map reader to have it shown in the metric as well as in the national system of measurement, if such are different.

The scale of a map showing manufacturing statistics varies according to the importance and spatial concentration of the manufacturing industry. If the manufacturing industry is centered in one region of the country, it is appropriate to restrict the map to this region, thereby enabling the scale to be increased or the format to be decreased. If the manufacturing industry is dispersed over the whole country but has one or two regions of greatest concentration, these must be shown on a larger scale in insets.

For the Province of Alberta, the manufacturing industry is dispersed throughout all census divisions, but is predominantly concentrated in Edmonton and Calgary. Since maps of manufacturing in Alberta are used for showing the locations of industries and overall development of each census division, all aspects of the manufacturing industry of Alberta should be presented as comprehensively as possible. Therefore, the scale of the map should be able to portray the whole picture of Alberta.

III. Map Projection

All maps are compiled on the framework of a grid system, which is a representation of the imaginary graticules of the curved surface of the earth. The projection used governs the shape and qualities of the matrix upon which locations are established. The aim of the employment of any projection is to systematically transfer location of points from the earth's surface, a sphere, to the map, a plane.

When a large segment of the earth's surface must be projected onto the map plane, there is a considerable difference between the geometrical nature of the curved surface of the earth and the flat surface of the map. Thus the transference between them will result in the distortion and deformation of the original picture.

All projections have distortions -- there is no map which can give an exact replica of the globe. The amount of distortion depends upon the location, size, and shape of the area to be mapped. Distortion is least in the representation of a small, compact country and greatest in maps of the whole world. The four variables -- direction, area, shape and distance -- usually determine the choice of origin, aspect, and class of a suitable projection. The primary aim of a logical choice is to select a projection in which the extreme distortions are smaller than would occur in any other projection used to map the same area, and which retains those characteristics of geometry and design most useful to the purposes of the map. A careless choice of map projection often leads to misrepresentation of the original picture.

In navigation and surveying maps, the most important requirement for the choice of map projection is one which can provide a good indication of direction; while in population mapping, since the area of the map strongly affects the picture of distribution and density of population, an equal-area projection is usually applied. For industrial mapping, since information is seldom related to direction or area, no specific projection is required.

As it is very costly and time-consuming to create a new map projection, it is wiser to use as a base map a map already compiled with the best selection of projection. In this thesis, the base map, duplicated from the Atlas of Alberta is based on a Lambert conformal conic projection.

IV. Selection and Generalization of Data

Cartographic generalization is born of the necessity to communicate. It is quite impossible to portray all characteristics and detail of a particular subject without the large reductions required for most maps. In order to portray the important aspects of reality, generalization and selection of data to be mapped are necessary.

The cartographer must generalize both the content and the symbolization of the map. Generalization in content is accomplished through the elimination of unimportant information, through the classification of data, and through the analysis of data for particular patterns. This procedure belongs to the aspect of cartographic method termed 'intellectual generalization' by

Robinson.[2] The generalization of information through the use of symbols and the generalization of symbols has been termed 'visual generalization'.

Classification is a standard intellectual process of generalization that seeks to sort phenomena into classes in order to bring relative order and simplify the complex differences or unmanageable information. It is difficult to imagine any intellectual understanding, beyond the very elementary, that does not involve classification. For example, thematic cartography is mainly concerned with distribution maps, and a large proportion of these portray quantitative data. The majority of these maps must separate the data into a given number of classes so as to be able to communicate the data through various patterns, tones, and so on. The selection of class intervals for use on such maps is a fundamental kind of generalization.

The selection of data involves the choice of information to be used to illustrate particular phenomena cartographically. If the cartographer is required to select and generalize the data in varying degrees, several considerations must be taken into account: the subject of the map, the availability of data, the reliability of the data, the map scale, and the amount of detail required.

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[2] A.H. Robinson, The Look of Maps, An Examination of Cartographic Design, Madison, 1952, p. 12.

The cartographer is often restricted in his choice of data to that which is available. If the data is available but incomplete, the cartographer may be required to substitute less effective elements to illustrate a subject. Therefore, the lack of quantitative information will affect the method of symbolization, so the subject may be mapped without detail. Where, for example, detailed municipality information for Alberta is lacking, form representation through shading or some similar means can be used to indicate the general trends of manufacturing in each census division.

V. Symbolization of Data

All information on a map is presented by means of symbolization, since the map is a symbolic image of real phenomena. A symbolic image can be regarded as a visible representation of phenomena to which meaning can be attached. The information on the map is translated from written words into graphic form, which can be perceived visually.

Map symbols can be classified into two main categories: (1) quantitative, and (2) qualitative. The former show the number of features present and the latter their characteristics. It is easier to manipulate the qualitative symbols than the quantitative symbols. To map phenomena of different kinds, the compiler needs simply to choose the types of symbol which have the best form association. But to show the degrees of variation in number or quantities, the compiler has to use his judgement on the changes of the size of the symbols proportionally to the change in magnitude of the quantitative values. He also has to consider especially the abrupt changes or extreme contrasts in the data and has to design the symbols to delineate this sharp contrast with fidelity. This is necessary because the ability of the map user to judge the significance of the size or arrangement of the symbols is an essential link in the process of transferring the map's message to its user.

The basic requirements of a good quantitative map symbol are simplicity and effectiveness. The cartographer has to take into consideration both visual and non-visual characteristics of the symbols.

The non-visual aspects include the ease of conversion of data into map symbols using uncomplicated calculation processes. The placement of the symbols on the map should not be time-consuming.

As far as the visual attributes of map symbols are concerned, they should be effective in creating an immediate and long-lasting intellectual response, so that reference to the legend can be kept to a minimum. And from the clarity and simple form of the symbols, we should be able to assess the quantity quickly and with a fair degree of accuracy.

Industrial data can be expressed cartographically by means of various types of symbols, the choice depending entirely upon the map's purpose. For example, to present different types of industry or the number of establishments, geometrical symbols are the most suitable ones; while for the ratio or intensity of industry, the choropleth method can be applied. Since industrial statistics usually involve great ranges of value, proportional symbols have often been used in order to avoid clusters of symbols. Generally speaking, of the different types of proportional symbols, proportional circles are most commonly used to show magnitude of industry.

CHAPTER III

CARTOGRAPHIC METHODS USED FOR INDUSTRIAL MAPS

The major task of the map is to convey information, ideas and concepts to the [illegible] reader convincingly and accurately. If the map is an attractively produced, well-balanced design, it will be more informative and satisfying visually, and will more easily capture and retain the reader's attention. Therefore, the cartographer must utilize the most appropriate graphic techniques to facilitate understanding of the subject mapped, and to achieve a high standard of legibility and aesthetic appeal.

The function of thematic maps is changing statistical data into a form in which patterns of distribution and spatial relationships can be recognized at a glance. The advantage of this type of presentation is that data are not portrayed as crude statistics but in an ordered, classified, symbolized and more readily understandable graphic form.

V.C. Finch remarks that "No other of the social studies than economic geography insists upon so rich a symbolization of its facts and concepts in cartographic form".[1] For portraying manufacturing data on maps, several cartographic methods are available, and the cartographer must be aware of the effects of variations in his choice of methods.

I. Cartodiagrams

Cartodiagrams employ statistical graphs and diagrams to express the variation of a particular phenomenon from one unit area or one specific location to another. It can use administrative areas as the basic units for which the graphs or diagrams are produced, or it may represent the statistical data of a specific point.

Because there are many types of graphs and diagrams, there can be a large variety of cartodiagrams. The following discussion is restricted to those which are most common and suitable in industrial mapping. Within this general group, the various types of graphs and diagrams will be classified into three sections.

A. Repeated Symbols

This method can be either of the simple or geometric kind, or of a pictorial or descriptive nature. Each value is represented by a number of small symbols arranged to form a composite pattern unit.

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[1] V.C. Finch, 'Training for Research in Economic Geography,' A.A.A.G., Vol. 34, 1944, p. 213.

The advantage of using this method is that the value of each repeated unit symbol is easily ascertained by counting the small units of which it is composed and multiplying by whatever unit value has been assigned. But in general practice, the use of repeated symbols demands comparatively more space on the map than geometrical symbols, and hence their use is often thwarted by the map scale.

This method is usually used when the range of numbers is not too big, and is therefore best for portraying manufacturing data such as number of establishments.

B. Graphs

1. Line Graphs

The line graph is the simplest way of relating one variable element with another. In such a graph one variable, which is often related with time, is called the independent variable and changes steadily. The other variable is termed the dependent variable and has markedly irregular changes. The independent variable is normally plotted against a horizontal axis, while several dependent variables may be plotted on the same graph against a vertical axis.

A series of values are plotted according to the appropriate values on each graduated axis. In order to emphasize the relationship between these plotted values, a line is used to join all these plotted points.

The line attracts attention to such features as maximum and minimum values and particularly to the tendency of values to rise or fall in any part of the graph.

This method emphasizes the actual amounts by which values increase and decrease over a period of time, and might best be used to portray manufacturing statistics such as changes in value added in each census division, 1961-1971; changes in manufacturing employees, 1961-1971; and so on.

On other occasions it may be more important to consider the rate of change rather than the amount. This can be done by plotting a logarithmic graph in which a logarithmic vertical scale is used in conjunction with a normal horizontal scale. This method will be discussed later.

2. Bar Graphs

For this method, the values are represented by a series of vertical or horizontal bars which run from the plotted points to the abscissa. Usually each bar is kept distinct from its neighbour, but this is not absolutely necessary.

The bars are simple to draw, and the effect is rather similar to the line graph. The tops of the bars trace out any rise or fall within the distribution, and at the same time the presence of the bars themselves attracts attention to the actual quantities. This method is particularly suitable when the data represent values which are quite separate and distinct from the preceding and succeeding ones, the break between the bars emphasizing this distinction.

The disadvantage of this method is that if there is a range of quantities of any great extent, it is very difficult to design the bars. For example, a quantity 100 times larger than another needs a bar 100 times as long. Therefore there must be some bars so small that they are almost invisible or so long that they have to be broken up into sections. This inconvenience can be overcome by applying the log scale device.

3. Logarithmic Graphs

The logarithmic graph mentioned here only includes the type whose vertical scale is logarithmic. As the numbers on the vertical scale are spaced according to the difference between their logarithms, therefore this graph can show the rate of increase as well as amount. The logarithmic graph is useful for figures which contain a large range which would be difficult to accommodate on the normal line graph. However, it is true that logarithmic graphs are not likely ever to be accepted popularly as line graphs are, therefore are less frequently used.

C. Diagrams

1. Proportional Circles and Divided Proportional Circles (Pie Graphs)

Proportional circles are used in manufacturing mapping to express the magnitude of manufacturing by the size of a circle. As such circles, by their different sizes, arouse an immediate visual and intellectual response on the part of the map user, the proportional circle is extremely successful in presenting an explicit picture of magnitude of manufacturing. Information such as number of manufacturing employees, total value added, and total value of manufacturing shipments, all of which are directly related to the importance of manufacturing centers, may be best presented by proportional circles.

Proportional circles, using different sizes of circle to represent the values proportionally, are very commonly and widely employed. According to J.J. Flannery,[2] proportional circles have demonstrated the following advantages:

(a) It is relatively easy to convert basic quantitative cata into symbolic form.

(b) Circles can be placed on a map more rapidly than other types of point symbols.

(c) Circles use map space efficiently, at least when compared to bars.

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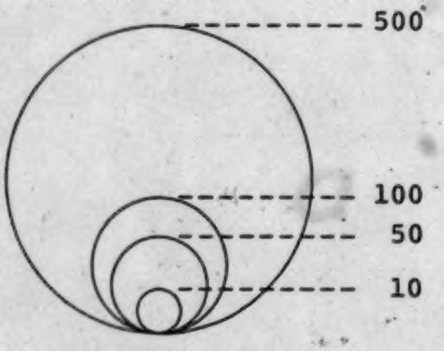
[2] J.J. Flannery, 'The Relative Effectiveness of Some Common Graduated Point Symbols in the Presentation of Quantitative Data', The Canadian Cartographer, Vol. 8, December 1971, No. 2, p. 97.

(d) Aesthetically, map users prefer circles (62%) over bars (38%).

(e) Circles represent patterns of distribution reasonably well.

There are several different techniques for designing the scale of circles; however, these can be mainly classified into two types:

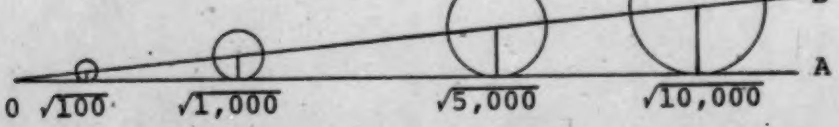
(a) In this technique, the area of the circles is proportional to the value they represent. Since the area of a circle is πr^2, and since π is constant, the method of construction is simply to extract the square roots of the data and then construct the circles with radii or diameters proportional to the square roots. As long as the radii are a linear function of the square roots, the areas of the circles will be proportional to the values they represent.



The weakness of this linear scale device becomes apparent when the range of values is very great. In this case, the cartographer cannot effectively show both ends of the range using graduated circles. If he allows for symbols large enough to be differentiated clearly in the lower end of the scale, then those at the upper end will overshadow everything else.

(b) The second technique for determining the radii of circles is most frequently used to portray information with a great range in value.

The square root of each value is found and plotted on a line-scale measured from zero on the left. The distance measured is proportional to the square root of each value. An oblique line is then drawn through the zero, the angle depending on how large the maximum symbol is to be. A vertical line drawn from the line-scale at any point to meet the oblique line will give the radius of a circle, the area of which is proportional to the value whose square root is represented at that point.

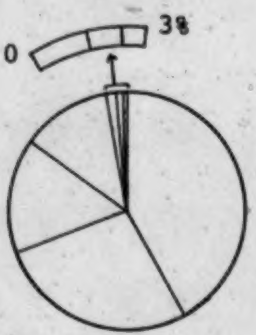


The size of the largest circle can be controlled by the assigned angle, and the circles between the minimum and maximum values are gradationally increased. Therefore the circles can readily be designed so that the largest one will not be too large while the smallest one will not be too small. This type of radius design is thus more suitable for portraying statistics with great range. (For detailed construction procedure see Appendix D.)

Regardless of size, the proportional circle itself is limited to representing total quantities. However, the circle can be divided into proportional segments which indicate the percentage of a total value represented by different components. This method is called the divided proportional circle or the pie graph method.

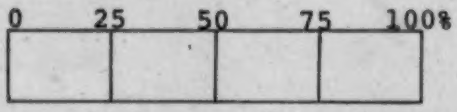
The pie graph method gives good results when comparison of a few items is desired. For example, it is suitable to show manufacturing information such as percentage of male and female employees, or percentage of types of establishment (food, chemical, textile, and so on). The pie graph permits comparison of proportional values within each diagram over the entire map.

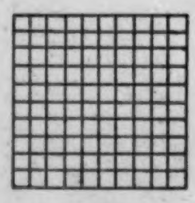
A disadvantage of this technique is that it may be very difficult to differentiate the relative values portrayed, if too many items are included within each circle. This is especially so when several small sectors are of approximately the same size. In this situation magnification of the small sector is necessary.



2. Divided Rectangles (Hundred Percent Rectangles)

The basic principle of this method is similar to that of divided circles. This method has certain advantages in the presentation of proportions and in making comparisons over the map area. Each rectangle is divided into 100 equal units; therefore the components of the rectangle indicate percentages much better, or more precisely, and have greater visual impact than the segments of a circle. The components are readily measured; thus they can express the absolute values as well. Consequently, the comparison of both proportional and absolute values of





components among individual rectangles can be made. Besides these advantages, the method is superior to that of divided circles especially when numerous subdivisions of manufacturing data have to be shown. Such is the case, for instance, in portraying types of establishment in manufacturing industry.

The method can be simplified, as in the case of divided circles, if only the percentages are of particular interest. In such an instance the rectangles can be replaced by uniform squares divided into 100 equal parts. Such simplification makes comparisons of numerous items even easier.

On the whole, for interpreting values divided rectangles have an advantage because they can be divided into equal units, making an assessment of quantity easier than is possible with divided circles.

3. Three-Dimensional Symbols

Three-dimensional symbols may be used when an exceptionally wide range of data has to be dealt with. The symbol can be a sphere or cube design, and the volume of the symbol is proportional to the cube of the radius (for sphere symbols), or the cube of the side (for cube symbols). In this case, a symbol 10 times larger than another will now represent a value 10^3 or 1000 times as great. Therefore, within a given range of symbol size, a very much wider range of value can be accommodated.

Well-designed three-dimensional symbols are very pleasing visually, but they do not serve the purpose of effectively portraying the exact numbers they are supposed to represent. Most map readers evaluate the spheres, not on their volume comparison, but rather on the basis of the map areas covered by them. Estimation from spheres or cubes is very difficult and inaccurate; furthermore, drawing of the symbols is far from easy.

II. Choropleth Method

The choropleth is one of the simpler methods for translating statistical ratios (e.g., % change of value added/unit time) into map form. Data gathered by enumeration areas, which also serve as basic areal units for this method, are arranged for grouping into classes and each class is then assigned a graded colour value, using either graduation in black and white or another colour, in a corresponding unit area.

The data for the choropleth method of mapping is usually related to administrative areas. Therefore this method has one major weakness in that it shows a uniform distribution within each area, taking no account of what may be important local variations and also giving the administrative boundaries themselves an importance completely divorced from reality.

Nevertheless, manufacturing information is different from data such as population information, for which the choropleth method is weak. In population mapping, the density of population is the ratio between number of people and area; therefore the sizes of the areas involved becomes important. On the other hand, manufacturing information seldom relates to the area of a place. For example, for percentage increase in value added or percentage increase in production, the focus of interest is on the specific ratio values at particular places, i.e. administrative or enumeration areas. Therefore, using an administrative area as a boundary to portray such ratios on maps is the only possible way. In these cases, the choropleth method is most suitable.

The advantage of the choropleth method lies in its simplicity as far as the reader is concerned. When well applied and executed, it gives a clear picture of intensity of the phenomena under consideration as well as forming a basis for comparisons.

CHAPTER IV

ILLUSTRATION OF CARTOGRAPHIC SOLUTION: SOME INDUSTRIAL MAPS OF ALBERTA

Manufacturing data can be expressed cartographically by means of various techniques, the choice depending entirely upon the purpose. The aim of this chapter is to explore the applicability of various methods of the representation of manufacturing data for which each particular method is the most suitable.

The maps that follow portray the manufacturing industry in the Province of Alberta. In this province, an excessively large range of figures occurs within each category of manufacturing data, such as value added, number of employees, and so on. Therefore, Alberta is ideal for studying the various techniques employed to depict such data.

All statistics used for compiling the maps have been supplied by the Alberta Bureau of Statistics. These statistics contain two sets of information: one considers manufacturing activity within each census division as a whole; and the other considers each main center (with 2500 population and over) in the province. Therefore, for the information concerning manufacturing in each census division, a base map with census division boundaries is used;

while for the information concerning manufacturing activity in main centers, a base map with the location of those centers is used.

The base maps are duplicated from the Atlas of Alberta, on a scale of one inch to 31.5 miles and one inch to 52.1 miles, as compiled in 1967 by the Government of Alberta and the University of Alberta (Department of Geography). All the maps have been reduced photographically to a convenient size (scale: one inch to 88.8 miles). A consistent map scale is used in all the sample maps of the study to ensure an easy comparison of the size of map symbols and the effects they create. Two maps showing the location of census divisions and centers with 2500 population and over (Figures 1 and 2) have been prepared to aid the orientation of each census tract and location of each center within the sample maps themselves.

Different treatments are applied for these two sets of data. They are discussed on the following pages.

I. Sample Maps Portraying Manufacturing Information Based On Census Divisions

A. Sample Maps Showing Number of Establishments

Repeated symbols method, i.e. repeated squares is used in Figures 3 and 4 to illustrate the available information on number of manufacturing establishments.

In both maps each square represents 4 establishments. For those census divisions where the number of establishments is not a multiple of 4, the square unit has to be subdivided into 4 parts (each part representing one establishment). The correct number of parts plus whole squares is then used to represent the total figure. For example, a census division with 7 establishments is represented by a square plus 3 subdivided-parts.

In Figure 3, the number of establishments in each census division is represented by squares which are directly proportional to the number represented. In order to give the map reader a quick means of counting the actual number of establishments, especially in those census divisions with a large number, a different arrangement of squares is used in Figure 4. Here each block is limited to 5 squares, and each 5 blocks is treated as a unit. This means that each block represents 20 establishments and each unit represents 100 establishments. This treatment can give the map reader a more immediate impression of the number of establishments than Figure 3. Therefore the latter method is therefore more advisable for portraying this kind of information.

The advantage of using the repeated-square method is that the map user, just by a glance, can understand where the establishments are concentrated and, at the same time, he can work out accurately the actual number of establishments.

The weakness of this method is that it needs large spaces to accommodate squares. When the number of establishments in a census division is too large, it is impossible to locate all the squares within the census boundary. In addition, the squares are too small for applying patterns to differentiate between the various groups of manufacturing, and colour differences within a subdivided-square are also impossible to see clearly. Therefore, this method is good for showing simply the number of establishments, without detailed information.

B. Sample Maps Showing Manufacturing Groups

When the range between number of establishments is great, the larger figures, which contain many squares, occupy lots of space and will tend to overlap adjacent census divisions. In this circumstance, the repeated-squares method is not efficient. A constant size of symbol, such as 100-percent squares or constant circles, can then be used to show the total number of establishments in each census division, and segments within the symbol can be used to indicate percentage differences between manufacturing groups.

In Figure 5 the 100-percent squares method has been used; each constant square is used to represent the total number of establishments in each census division as 100 percent. The constant square is subdivided into 100 smaller squares; each subdivided-square therefore represents one percent of the total number of establishments within a census division. In the study map (Figure 5), the subdivided-squares are so small that using different patterns to differentiate manufacturing groups is impossible; therefore colours have been applied in place of patterns.

The 100-percent squares method can give the map user a clear picture of the portion of manufacturing contributed by each manufacturing group (food, textiles, chemicals, and so on) in a census division. At the same time, since each square is a constant size, comparisons between squares are easy to make.

Another type of cartodiagram, the pie graph method, is applied in Figure 6 to show the same information as in Figure 5. In this method, constant circles are each subdivided into 100 sectors. Each manufacturing group is represented by a sector proportional to the percentage involved. Distinctive patterns are then applied to the sectors so that percentages can be compared visually over the entire map.

A conclusion can be drawn from these sample maps using the 100-percent square and pie graph methods to portray information on manufacturing groups. Both symbols are of constant size; therefore they are equally suitable for portraying data where the number of establishments varies greatly. If the actual number is placed beside each symbol, it is more convenient for the map reader; so that he may know the actual number of establishments in each census division as well as the percentage of that total figure which each manufacturing group represents.

The 100-percent square and the pie graph are both good for showing percentages. But the 100-percent square can indicate the percentage more accurately to the reader, who can easily count the small one-percent squares. The pie graph can give only a rough estimate unless the reader uses a protractor to measure each subdivision.

C. Sample Maps Showing Value Added and Percentage Changes in Value Added

Two cartographic methods: proportional circles and choropleth are combined in Figures 7 and 8 to illustrate the manufacturing information for Alberta of value added and percentage changes in value added.

The proportional circle is essentially a cartographic depiction of the distribution of absolute number or other quantitative value. The value portrayed is proportional to the size of each circle, therefore each circle can represent a higher value. In the Province of Alberta, the manufacturing industry is concentrated in census divisions 6 and 11. The total value added for these two divisions is $230,228,000 and $338,821,000 respectively (see Appendix B). In contrast, total value added in census division 4 is only $180,000. Such a great range of values creates difficulty in the design of symbols to represent them.

The scale of the proportional circle has to be chosen so that the smallest circle is not too small to be easily seen and the biggest is not so big that it overlaps too much of other census divisions. Each designed circle bears a distinct proportional relationship to the quantity represented. Two types of radius calculation are used in Figures 7 and 8 to show magnitude of value added in each census division. In Figure 7, the areas of the circles are proportional to the values represented, which means that the length of the radius is proportional to the square root of the value which a circle is intended to represent. As the map shows, because of the exceptional magnitude of value added from the manufacturing industry in census divisions 6 and 11, circles which are too large result.

In this map scale, the space available within the corporate boundaries cannot possibly accommodate these two large circles; therefore the circles have to be placed on the space at the side of the map. In order to use space more efficiently, these two circles are in half-circle form, and are placed side by side, so that a comparison of magnitude of value added can be obtained as well.

Another type of radius construction is used in Figure 8. The radii of the circles are controlled by the height at various distances along the assigned angle line (for more details on this method, see Appendix D). The resulting map shows that the largest circle is not as large as in Figure 7, and can therefore be placed within the corporate map boundary.

Comparing Figures 7 and 8, it is evident (as mentioned above) that when the range between values is great, using square roots of the values to construct the radii is no more efficient. The gradational circles method used in Figure 8 allows all circles to be located within the appropriate census division, so that only relatively small areas of adjacent census divisions have to be overlapped. Therefore, this type of radius construction is more advisable. Such a map gives the map user a clear image of the relationship between the value added which the circle represents and the geographic location of the census division which it belongs to.

The choropleth method is used in both maps (Figures 7 and 8) to portray the information of percentage changes of value added from 1961-1971. The choropleth method is ideal for presenting data in the form of ratios, percentages or proportions. Ratios are average quantities characterizing the unit areas as a whole and thus are appropriate where one quantitative areal symbols is wanted to represent the whole unit area. Conventionally, percentage changes of value added are expressed in a ratio form, since the data of value added are enumerated within census divisions. Therefore, these census division units are chosen as the 'control space' for symbolization.

> Choropleth has already gained some currency as the designation for an areal symbol bounded by the limit of political or other statistical subdivisions of the area mapped.[1]

The conventional way for applying different classes of tones or patterns in the choropleth method is to consider the census division boundary as the border. But there is a difference between the use of the choropleth method for portraying information about manufacturing data and population density. Population density is expressed in a simple arithmetic ratio denoting a stated number of people per unit area of land, while for information about percentage changes of value added, there is no relationship between the value and the area in each census division. The census division is just an arbitrary unit. Therefore, in Figures 7 and 8, different patterns are used to fill in the proportional circle, rather than the census division itself. This treatment minimizes complication of the map as a whole.

The cube method is used in Figures 9 and 10 to portray the same information as shown in Figures 7 and 8 on value added by manufacturing. If only one cube is used, the volume is proportional to the cube of its side. Therefore, when a cube symbol is 10 times larger than another, it represents a value 1,000 times as great. For the untrained human eye, this difference would not be properly realized. Therefore, in Figures 9 and 10, blocks of accumulated cubes are used. A block with more accumulated cubes thus represents, in a linear way, a higher value.

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[1] J.K. Wright, 'The Terminology of Certain Map Symbols,' Geogr. Rev., Vol. 34, October, 1944, p. 653.

For Figures 9 and 10, each cube represents 1,000,000 dollars of value added. The total amount of value added in each census division is shown by a block of accumulated cubes proportional to the value it represents. Each cube can be devised to represent a greater amount of value added; therefore, all blocks on the map can be fitted within the boundary of census division. Within each census division, the area not covered by the block area is covered by a distinctive tint (choropleth method), which represents the percentage of increase or decrease of the value added from 1961-1971.

All elements in Figure 10 are exactly the same as in Figure 9, except for the light yellow colour superimposed on the cube blocks. The purpose is to illustrate how the small effort of adding colour can greatly emphasize the information on value added of manufacturing industry, because the cube blocks stand out better from the background information (percentage changes of value added).

It can be concluded that when the situation allows for it, such addition of colour can present to the cartographer a much broader scope for symbolization and at the same time give the reader an aesthetically-pleasing map.

In comparison to the proportional circle method, we have concluded that cube symbols can be devised to represent a greater range of value added, so that all blocks can be located within the related census division boundaries. In addition, by counting the number of cubes, one can work out a far more accurate figure than by estimating the area of the circles.

Three-dimensional cube symbols are also more pleasing visually than two-dimensional circles, but we have to admit that drawing the cube symbols is much more time-consuming and involves more sophisticated cartographic techniques.

On the whole, using cube symbols as in Figures 9 and 10 is not only more pleasing visually, but can provide clearer quantitative as well as locational information. For the Province of Alberta, since there is such a range within figures of value added, it seems advisable to use cube symbols to portray such information.

D. Sample Maps Showing Gross Value of Production and Percentage Changes in Gross Value of Production

Two different devices of cube symbols are used in Figures 11 and 12 to portray the information on gross value of production.

In Figure 11, gross value of production in each census division is represented by accumulated cubes. Each cube represents $1,000,000 of gross value of production, therefore, the actual value will be shown by accumulating a certain amount of cubes which is proportional to it.

For counting convenience, each bar is limited to 10 cubes, and each row is limited to 10 bars.

The information on gross value of production is similar to the data on value added just mentioned, in that the range between values varies greatly. For example, census division 4 contains $288,000 of gross value of production, while census division 11 contains $876,773,000. In Figure 11, each cube is assigned a value of $1,000,000, so that the smallest cube in census division 4 can at least be seen. At the same time, in census division 11, which contains the greatest number of cubes can all be fitted within the boundary.

Another cube-symbol device is used in Figure 12 to portray the same information. In this map total gross value of production in each census division is now represented by only one cube. The volume of the cube is proportional to the cube of one side. Therefore, each cube is devised according to the cube roots of the data; that is, by making the sides of the cube proportional to the roots, so that the volume of the cube will be proportional to the value represented.

For this method, a figure 1000 times greater than another will only appear 10 times larger in the volume of the cube. When map readers evaluate the cubes, they are not comparing on the basis of the volume of the cube, but on the basis of the map areas covered by them. Therefore, they would not realize that when the volume of the cube changes a bit, it means that the actual figures change quite a lot. Therefore, readers tend to underestimate the results.

On the whole, using the proportional cube symbols, more value can be portrayed with a much smaller range of space covered. This, of course, makes it possible to portray graphically a larger range of data. But it is a pity that cube symbols do not serve the purpose of effectively portraying the numbers they are supposed to represent.

It is obvious that the advantages of the cube symbol are a pleasing visual appearance and the larger range of data which can be portrayed. This method is most suitable when used for statistics with a great range. On the other hand, in order to avoid underestimation from the symbol, the accumulated-cube device is more advisable to use than the proportional cube device, since, by counting the number of constant accumulated-cubes, a far more accurate figure can be worked out than by estimating the volumes of various proportional cubes.

The choropleth method is used in both maps (Figures 11 and 12) to show the information on percentage changes of gross value of production from 1967-1971. Census division boundaries are used to define unit area, and six classes of tint have been chosen to show the difference among changes of gross value of production within these areas.

E. Sample Maps Showing Total Number of Employees In Manufacturing, Male and Female

The contrast between number of employees in Alberta's census division is great; therefore, proportional circles are used in Figure 13 to represent total number of manufacturing employees in each census division. The size of the circles is proportional to the value represented.

The circles are placed within the census division boundaries. For those areas where overlapping of circles occurs, smaller circles are superimposed on the larger circles, as this will make the smaller one more clearly identifiable on the map.

Pie graphs with two divided sectors are used to differentiate percentages of male and female employees within each circle. Throughout all census divisions, male employees are much more numerous than female employees. Therefore, the sector which represents female employees is filled with a denser tint. This means that more area in the circle is covered by a lighter tint, so that overshadowing the boundary of a census division can be avoided.

In Figure 14, the bar graph method is used to represent the number of male and female employees. The scale of bar is in linear form. Both male and female employees are represented by bars of the same scale, and are placed side by side.

Since male employees are everywhere more numerous than female employees, the bar used to represent male employees tends to be so long that it cannot be contained within the census division boundaries, and breaking the bar into parts is the only solution. On the other hand, some bars used to represent female employees are so short that they almost cannot be seen.

For counting convenience, each complete bar is assigned to represent 1,000 employees, so the actual number of employees can be worked out by counting the bars.

Comparing Figures 13 and 14, we see that in Figure 13, using proportional circles, the magnitude of manufacturing employees is more effectively shown. Further, since the circles are divided into sectors, they can give more detailed information beyond the number of employees, such as percentage difference of male and female employees. Just by a glance at Figure 13, the map user can get a far clearer impression of these statistics.

In Figure 14, the advantage of using the bar graph method is that quantitative information can be worked out quite accurately by counting the bars. But if the range of values is too great, there are some extremely long bars which have to be broken into parts, and some bars are so short that they almost cannot be seen. In addition, by this method, percentage difference between male and female employees cannot be shown as clearly as in Figure 13.

From such comparison, one may conclude that the cartographic treatment used in Figure 13 (proportional circle and pie graph method) is more suitable to portray information on number of manufacturing employees and percentage difference of male and female employees.

II. Sample Maps Portraying Manufacturing Information Based on Centers With 2,500 Population and Over

The manufacturing information that follows is located at those centers with 2,500 population and over. Cartodiagrams are placed at the center of the locations; except for congested areas, where the cartodiagrams are placed as near the center as possible.

In order to avoid congestion of cartodiagrams and center names in areas with a concentration of centers, the names of the centers are replaced by Roman numerals. Figure 2, which gives complete names of the centers, is used as a reference map.

A. Sample Maps Showing Number of Employees in Manufacturing

In Figure 15 proportional circles are used to represent number of total manufacturing employees in each population center. The location of each center is used as the center of the circle.

In Alberta, centers with 2,500 population and over are mainly distributed in the central and southern parts of the province. Therefore, overlapping of circles in these congested localities is the only possible solution. On the other hand, since congestion attracts the eyes, it is to some extent useful for emphasizing important areas in the distribution.

The proportional circles are further divided into two sectors to represent percentage of male and female employees. When overlapping of circles results, smaller circles are superimposed on the larger ones. Thus, when part of the larger circle is overshadowed by a smaller one, the quantity of both can still be estimated. If it were the other way round, the smaller circle would be obscured by the larger one.

In Figure 16, the bar graph method is used to represent number of employees. Since the centers with 2,500 population and over are clustered in the central and southern parts of the province, if each bar graph is placed on the exact center of each location, some graphs tend to squeeze or even overlap each other. Therefore some bar graphs have to be shifted to be as near the center as possible and still avoid overlap.

Besides, the number of employees per center varies so greatly that it is difficult to design the linear scale for the bar. For example, the bar graphs used to represent number of employees in Edmonton and Calgary are so long that they must be broken into parts. In other centers (for example, Coaldale and Wainwright) the bars are so short that they are nearly invisible.

Considering the disadvantages of using bar graphs to portray information on number of employees, as evident in Figure 16, we should employ the proportional circle instead. The advantages of using proportional circles have been mentioned before (see pages 59-60); in addition, it should be pointed out that proportional circles are easier to construct and occupy space more effectively than bar graphs. In general, much higher values can be represented by the circle symbols. When overlapping of circles occurs, the values represented by them can still be estimated. The desirability of presenting different kinds of information together, such as total number of employees, and percentage difference of male and female employees, also makes proportional circles the more preferred method.

B. Sample Maps Showing Value Added

Accumulated cubes and proportional circles are used in Figures 17 and 18 to show information on value added for population centers.

In Figure 17, cubes are placed at the locational center of the centers represented, so that location and value added may be linked visually as quickly as possible. In Edmonton and Calgary, the blocks contain large numbers of accumulated cubes which, if placed at the center of the location, will overlap adjacent cubes. Such overlapping is by no means desirable for accumulated cubes, as underestimation will result for the overshadowed part.

To assist the calculation of the values which the cubes represent, a scale of cubes has been derived. This scale is represented in the map legend, as is the scale of circles in Figure 18.

Again, the accumulated-cube symbol is good for portraying values with a great range, and counting cube symbols is far more accurate than estimating proportional circle size with reference to the size of circles in the legend.

In Figure 18, using proportional circles to represent the same information, the locations of centers are used as the centers of the circles. When overlapping of circles occurs, smaller circles are superimposed on the larger ones.

The choropleth method is used to indicate percentage of value added in each center compared to total value added in the province. Five densities of tint have been chosen to fill in the proportional circle.

Comparing Figures 17 and 18, it appears that the combination of the proportional-circle and choropleth methods used in Figure 18 can portray efficiently both absolute value added and percentage of the total value added to the province. However, as far as the accuracy of the information received by the map reader is concerned, the accumulated-cube symbol is definitely superior.

C. Sample Maps Showing Gross Value of Production

The same type of cartographic treatment used in Figures 17 and 18 is applied to Figures 19 and 20 to portray information on gross value of production.

In Figure 19 proportional circles are used to represent the gross value of production in each center and the choropleth method is used to represent the percentage of gross value of production for the province. In Figure 20, accumulated cubes are used to represent the gross value of production in each center.

The advantages and disadvantages of using these methods are the same as mentioned for Figures 17 and 18 (see above, pages 63-64).

D. Sample Map Showing Total Number and Location Quotient of Employees in Manufacturing

The mathematical method used in the Economic Atlas of Ontario for measuring location quotient[2] of manufacturing employees is applied in Figure 21.

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[2] Location quotient measures the degree to which a specific areal unit has more or less than its share of any particular economic activity. In technique, location quotient is a ratio of ratios, and when mapped, absolute distributions of the activity are shown together with relative comparisons of the same distribution.

A location quotient of 1.0 means that a center has neither more nor less of the total manufacturing employment than its population would indicate. A quotient over 1.0 is indicative of concentration in a particular centre relative to the overall manufacturing employment. A quotient of less than 1.0 indicates that manufacturing employment is less in a particular centre than the population would lead one to expect. (Economic Atlas of Ontario, The University of Totonto Press, Toronto, 1969, plate 36.)

Since the location quotient is a ratio of two ratios, comparing one center with all centers,[3] the

---

[3] The location quotient of manufacturing employment for urban centres is calculated as follows:

Xi = manufacturing employment in each centre
Yi = total population in each centre
where i = 1,2,.........n urban centres

(1) Manufacturing employment by place of work in 1971 for all urban centres included in the study is summed.
(2) Manufacturing employment in each centre is expressed as a percentage of the sum for all centres.
(3) Total population in 1971 for all urban centres is summed.
(4) The population of each centre is expressed as a percentage of the total population for all centres.
(5) The location quotient for each centre is then computed by dividing the result of (2) by the result of (4).

To simplify, this may be expressed in algebraic terms as follows:

(1) $$\sum_{i=1}^{n} Xi$$

(2) $$\frac{Xi \times 100}{\sum_{i=1}^{n} Xi}$$

(3) $$\sum_{i=1}^{n} Yi$$

(4) $$\frac{Yi \times 100}{\sum_{i=1}^{n} Yi}$$

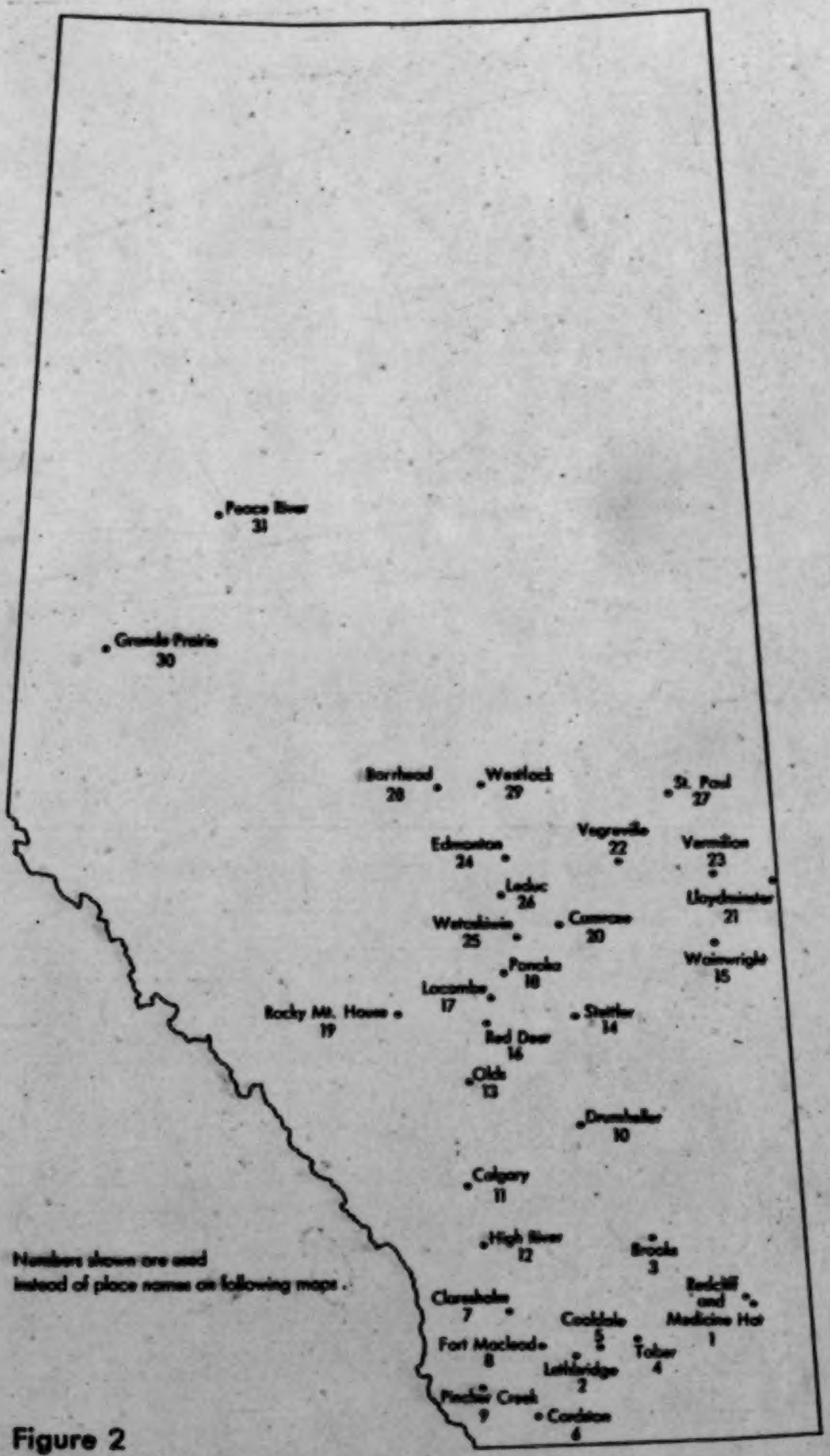
(5) $$\frac{\dfrac{Xi \times 100}{\sum_{i=1}^{n} Xi}}{\dfrac{Yi \times 100}{\sum_{i=1}^{n} Yi}} = \frac{Xi \sum_{i=1}^{n} Yi}{Yi \sum_{i=1}^{n} Xi}$$

(*Economic Atlas of Ontario*, The University of Toronto Press, Toronto, 1969, plate 36.)

choropleth method is the best technique for illustration purposes.

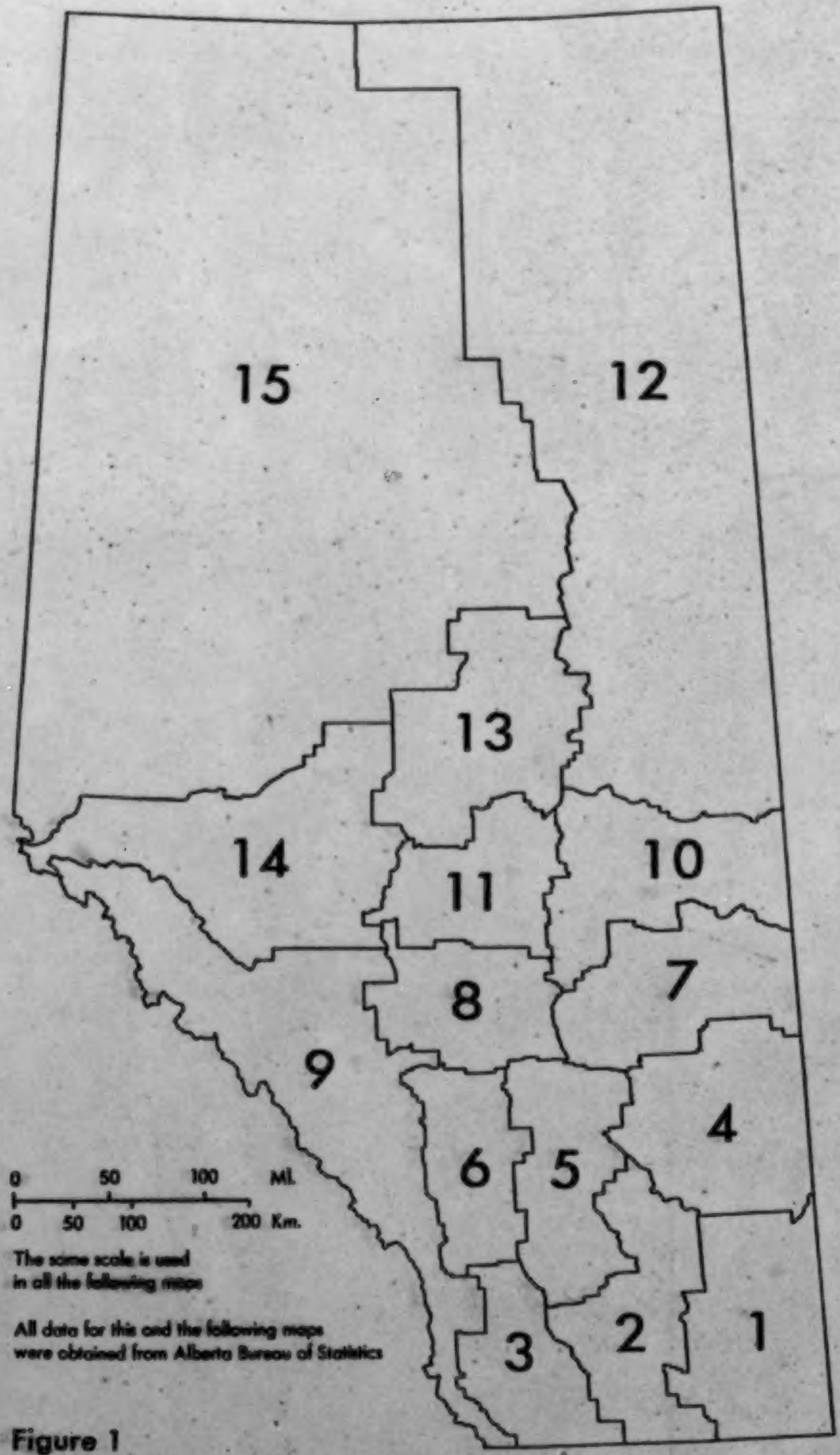
Proportional circles are used to show the absolute distribution of the manufacturing employees, and the choropleth method with 5 classes of tint is applied within the circles to show relative ratios of manufacturing employees.

From the maps discussed above (Figures 13 and 15), it was concluded that the proportional-circle method is best to use for portraying number of manufacturing employees and the choropleth method is best to use for portraying ratio information. Therefore the combination of these two cartographic methods seems the best choice for representing these two kinds of information simultaneously.



Numbers shown are used
instead of place names on following maps.

Figure 2
Alberta : Centers with Population 2,500 and over



The same scale is used in all the following maps

All data for this and the following maps were obtained from Alberta Bureau of Statistics

Figure 1
Alberta : Census Division

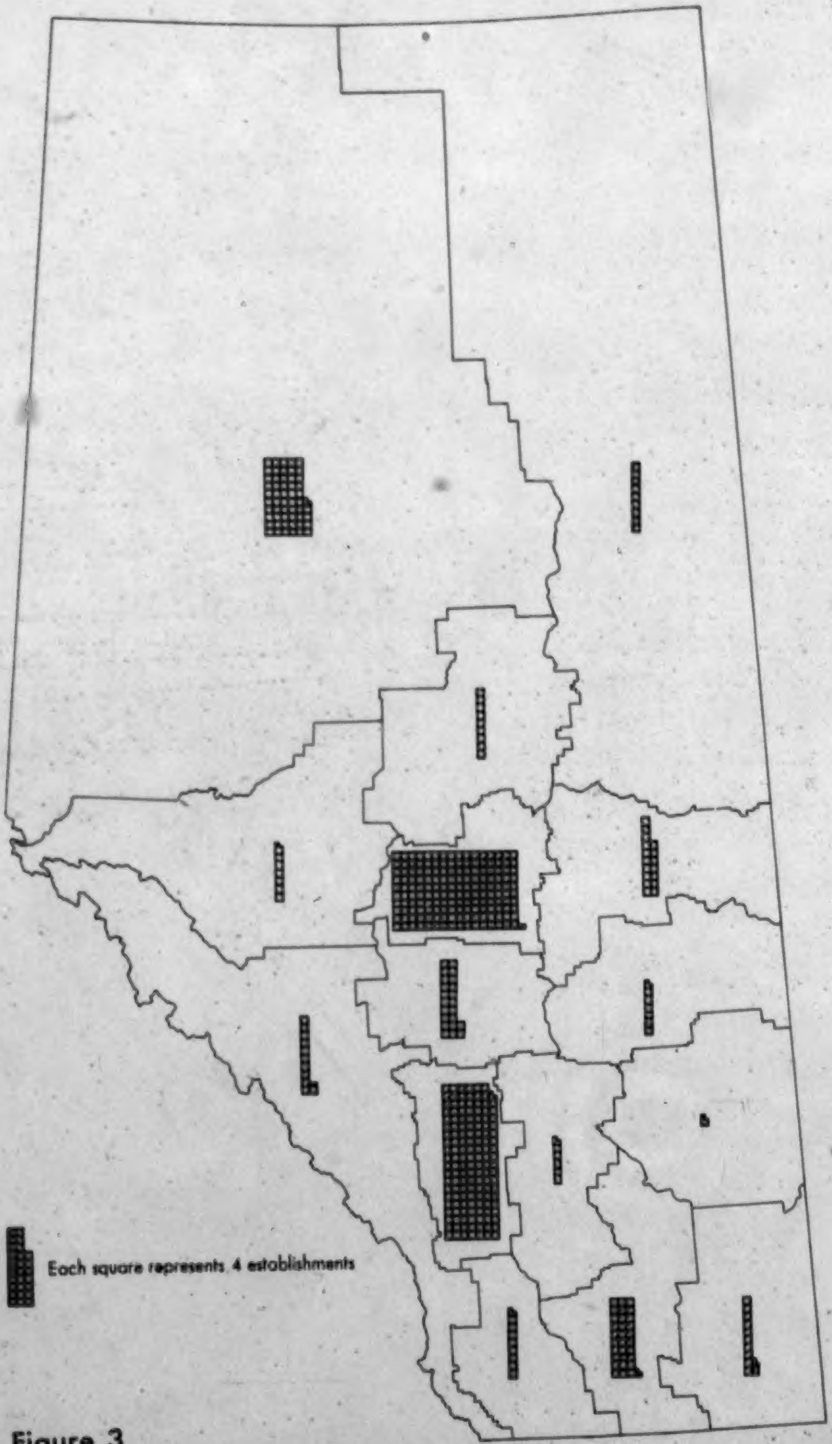


Figure 3
Distribution of Manufacturing Establishments
(per census division)

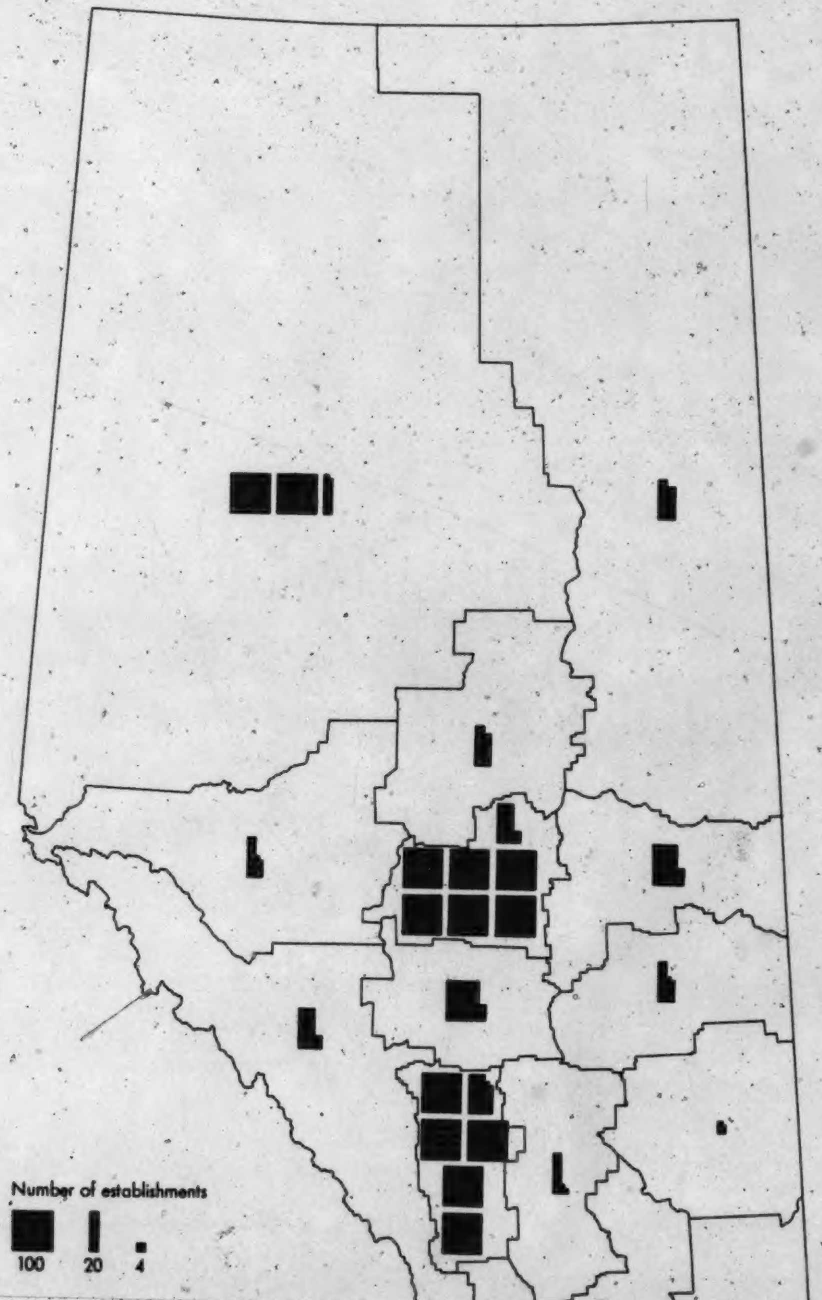


Figure 4
Distribution of Manufacturing Establishments
(per census division)

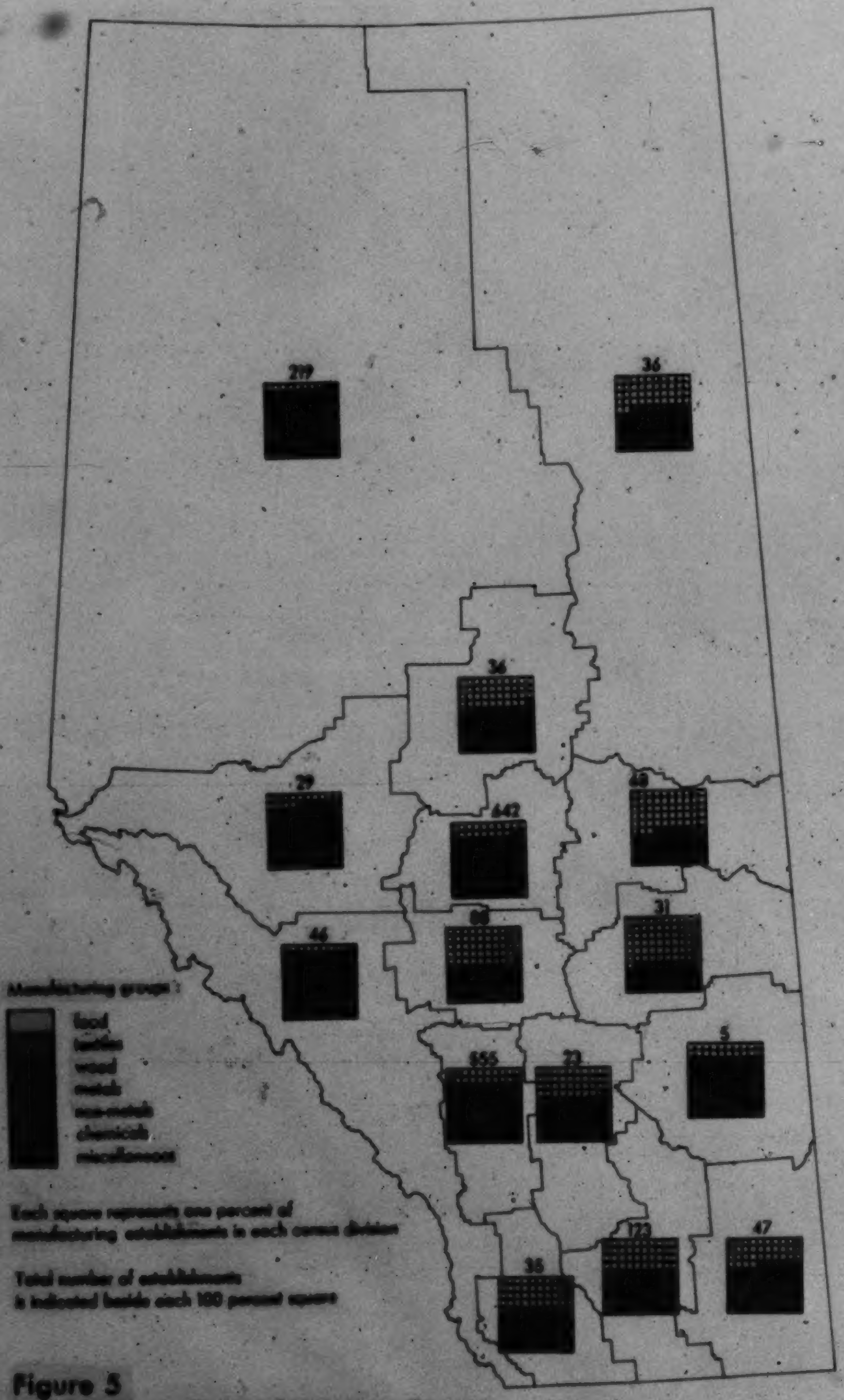

219
36
36
29
642
48
46
88
31
555
23
5
172
47
35
Manufacturing groups:
food
textiles
wood
metals
non-metals
chemicals
miscellaneous
Each square represents one percent of manufacturing establishments in each census division
Total number of establishments is indicated beside each 100 percent square

Figure 5
Distribution of Manufacturing Groups
(per census division)

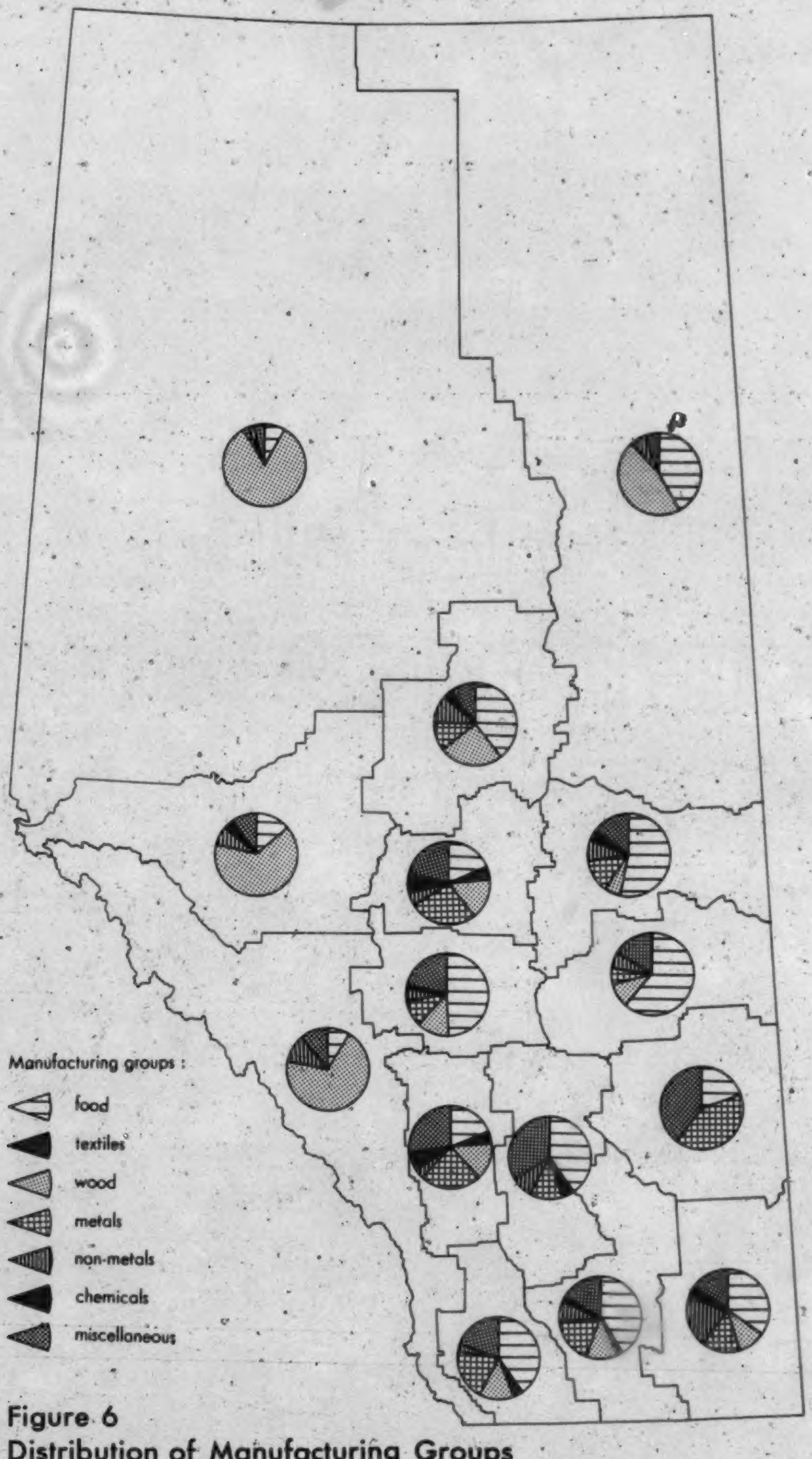


Figure 6
Distribution of Manufacturing Groups
(per census division)

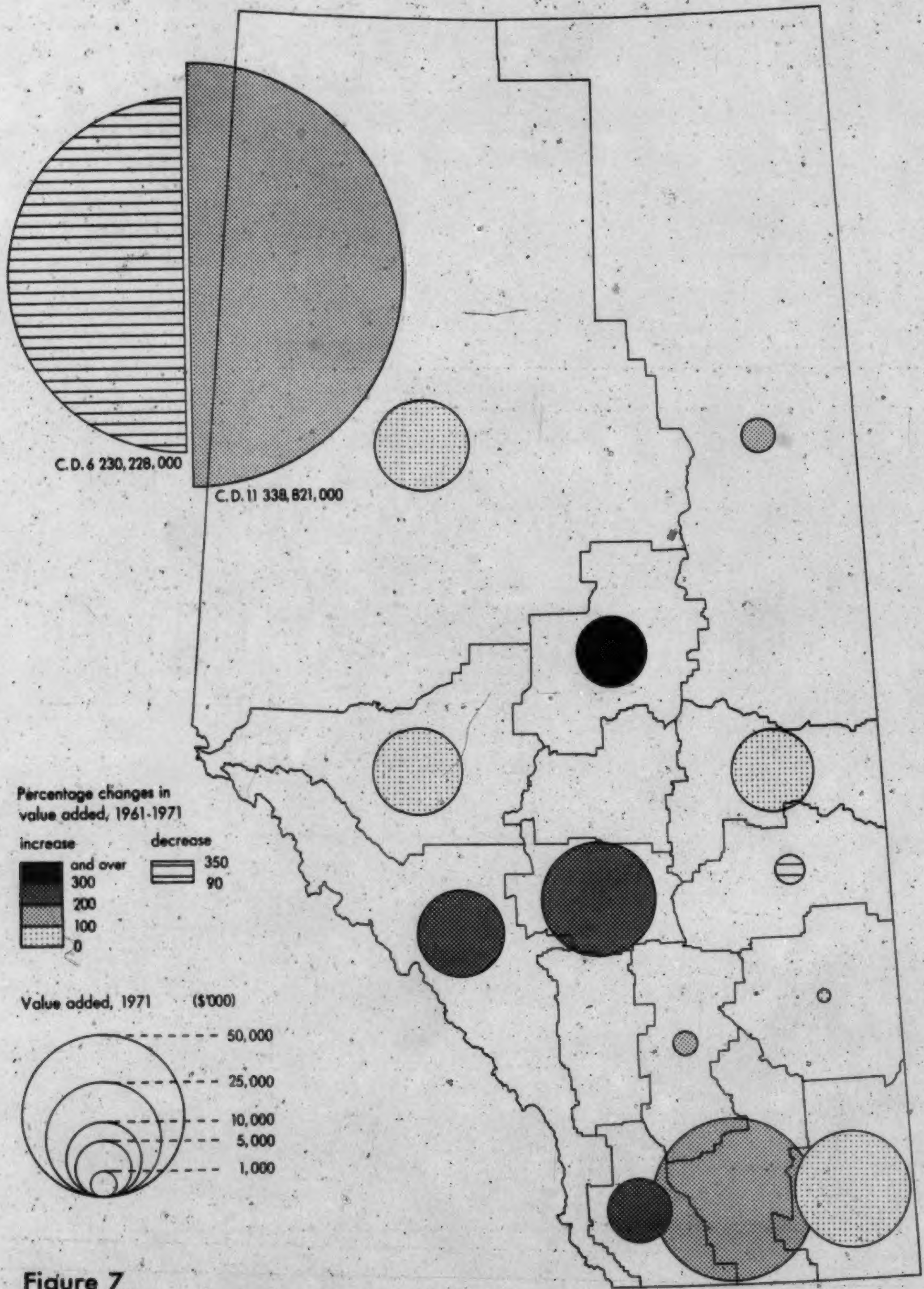


Figure 7
Value Added by Manufacturing
(per census division)

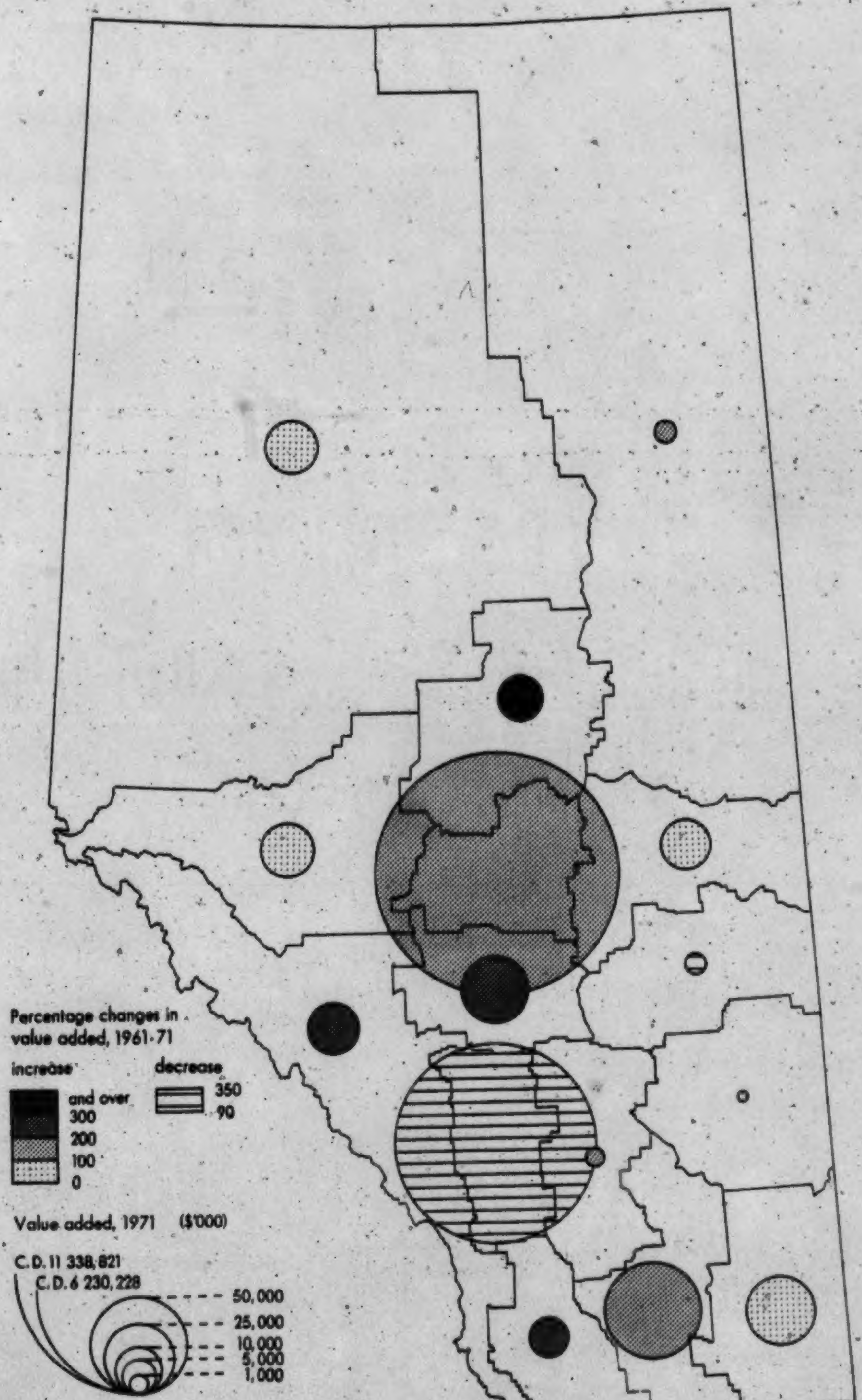


Figure 8
Value Added by Manufacturing
(per census division)

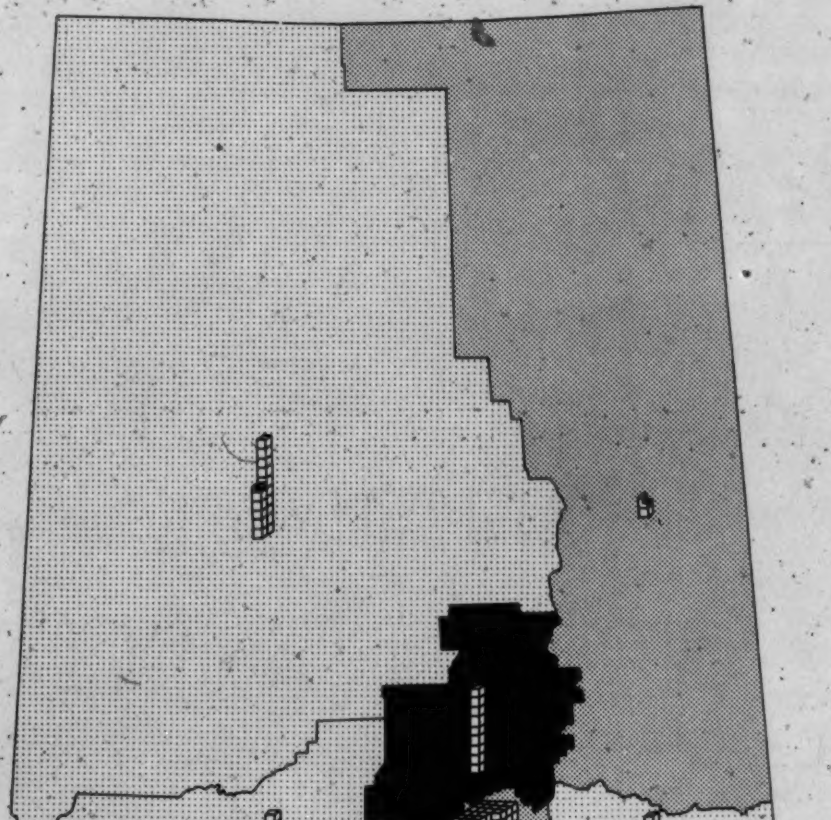


Figure 9
Value Added by Manufacturing
(per census division)

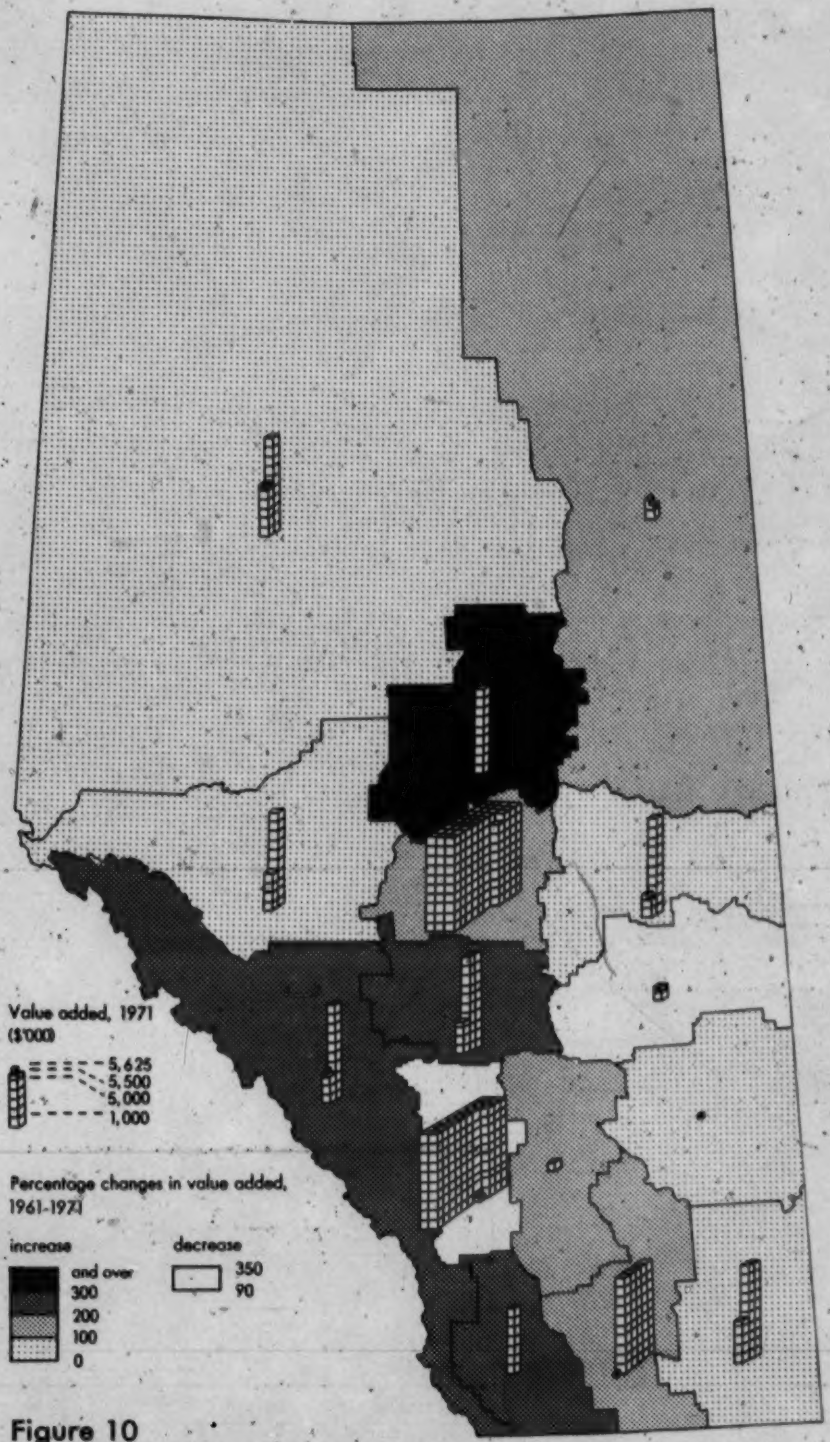


Figure 10
Value Added by Manufacturing
(per census division)

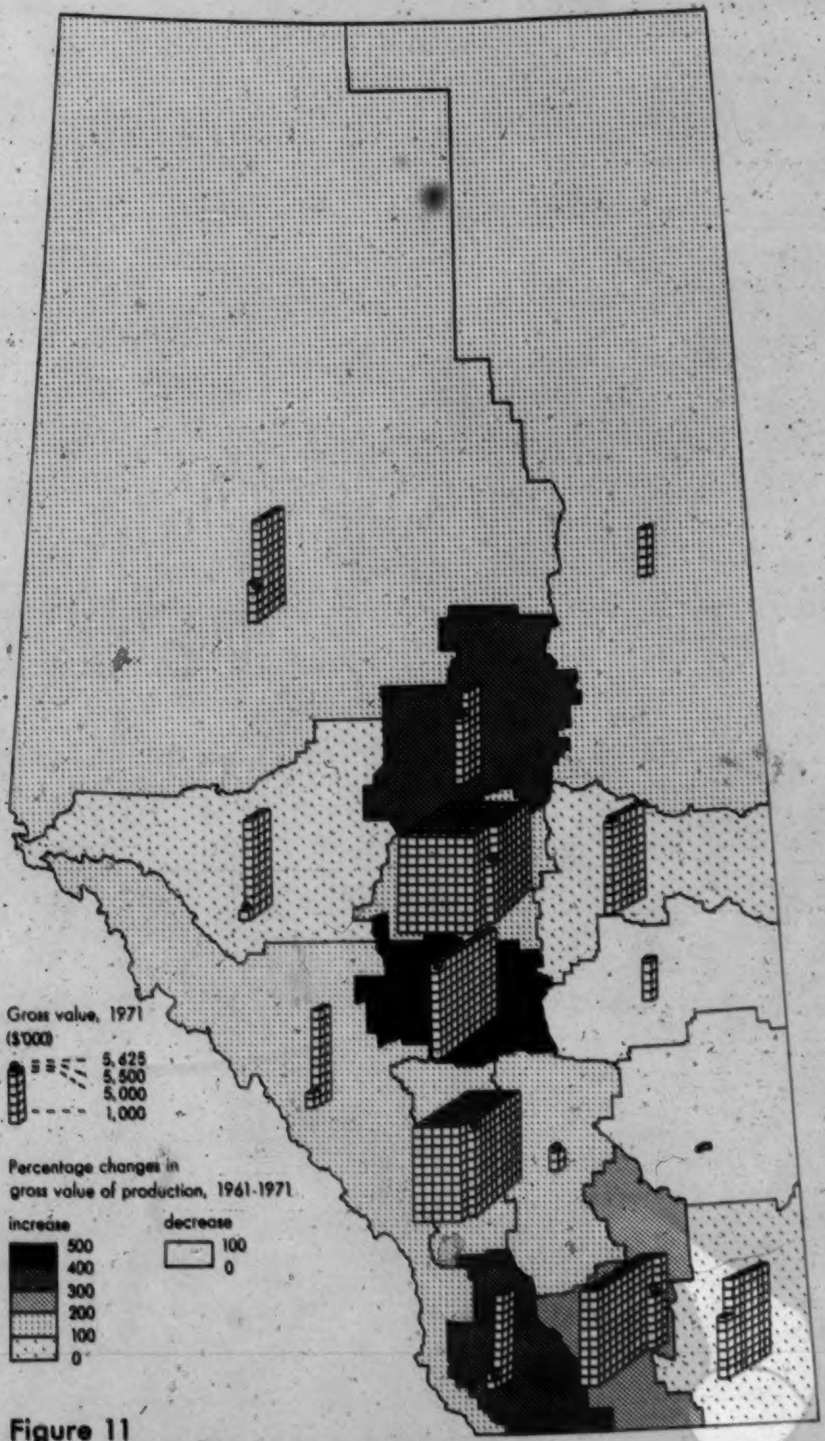


Figure 11
Gross Value of Manufacturing Production
(per census division)

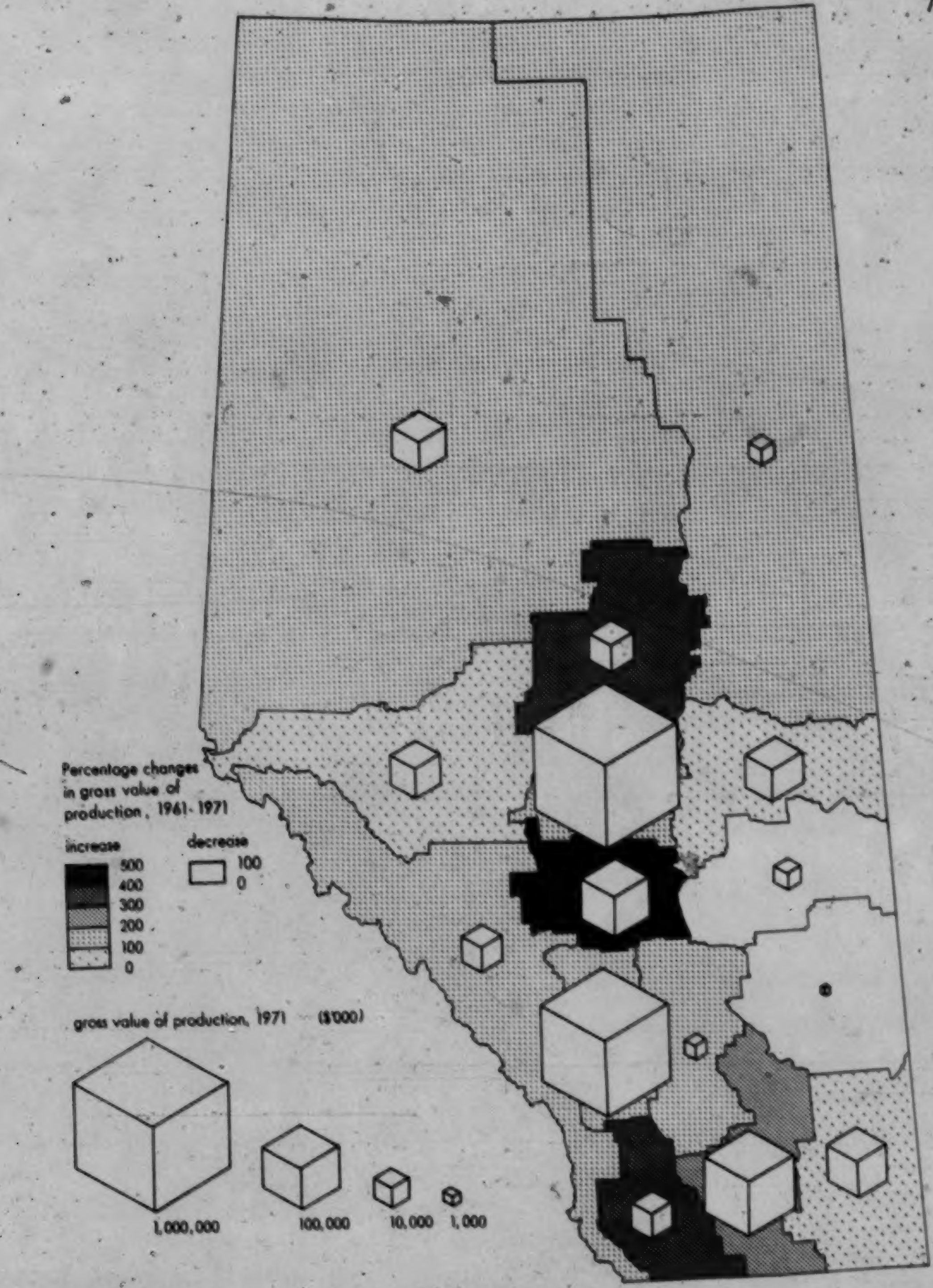

Percentage changes in gross value of production, 1961-1971
increase
decrease
500
400
300
200
100
0
100
0
gross value of production, 1971 ($'000)
1,000,000
100,000
10,000
1,000

Figure 12
Gross Value of Manufacturing Production (per census division)

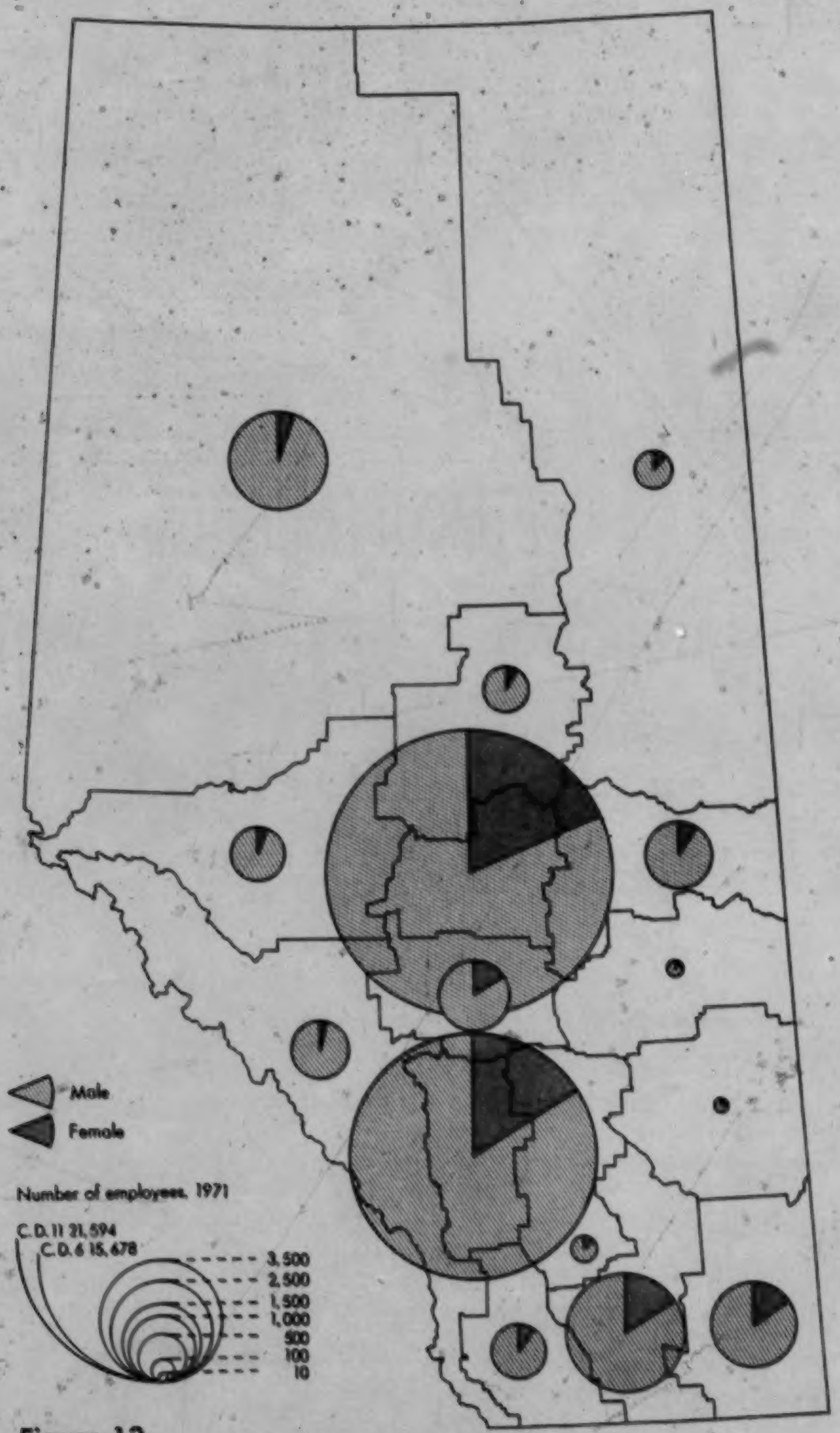


Figure 13
Distribution of Employees in Manufacturing
(per census division)

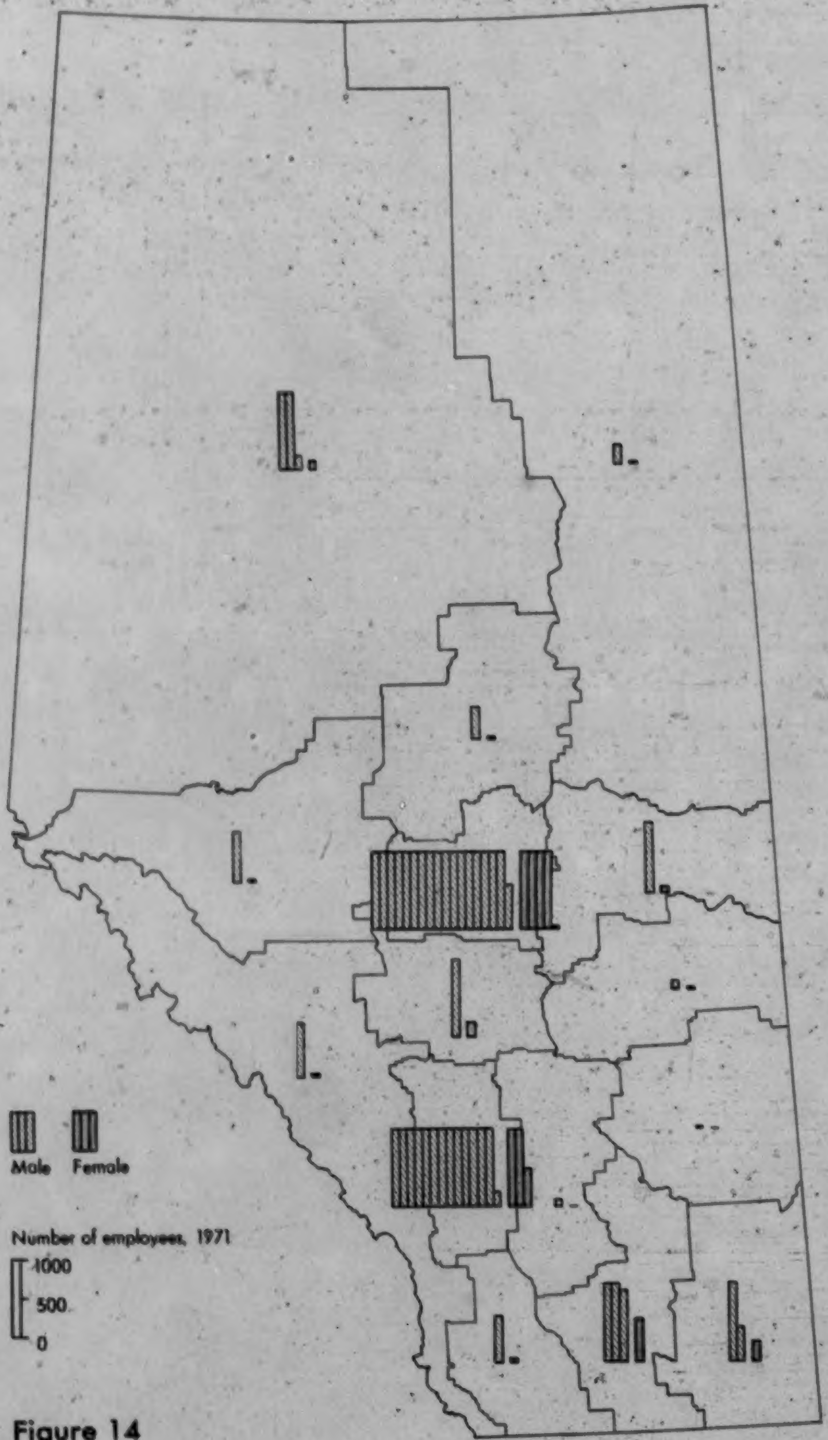


Figure 14
Distribution of Employees in Manufacturing
(per census division)

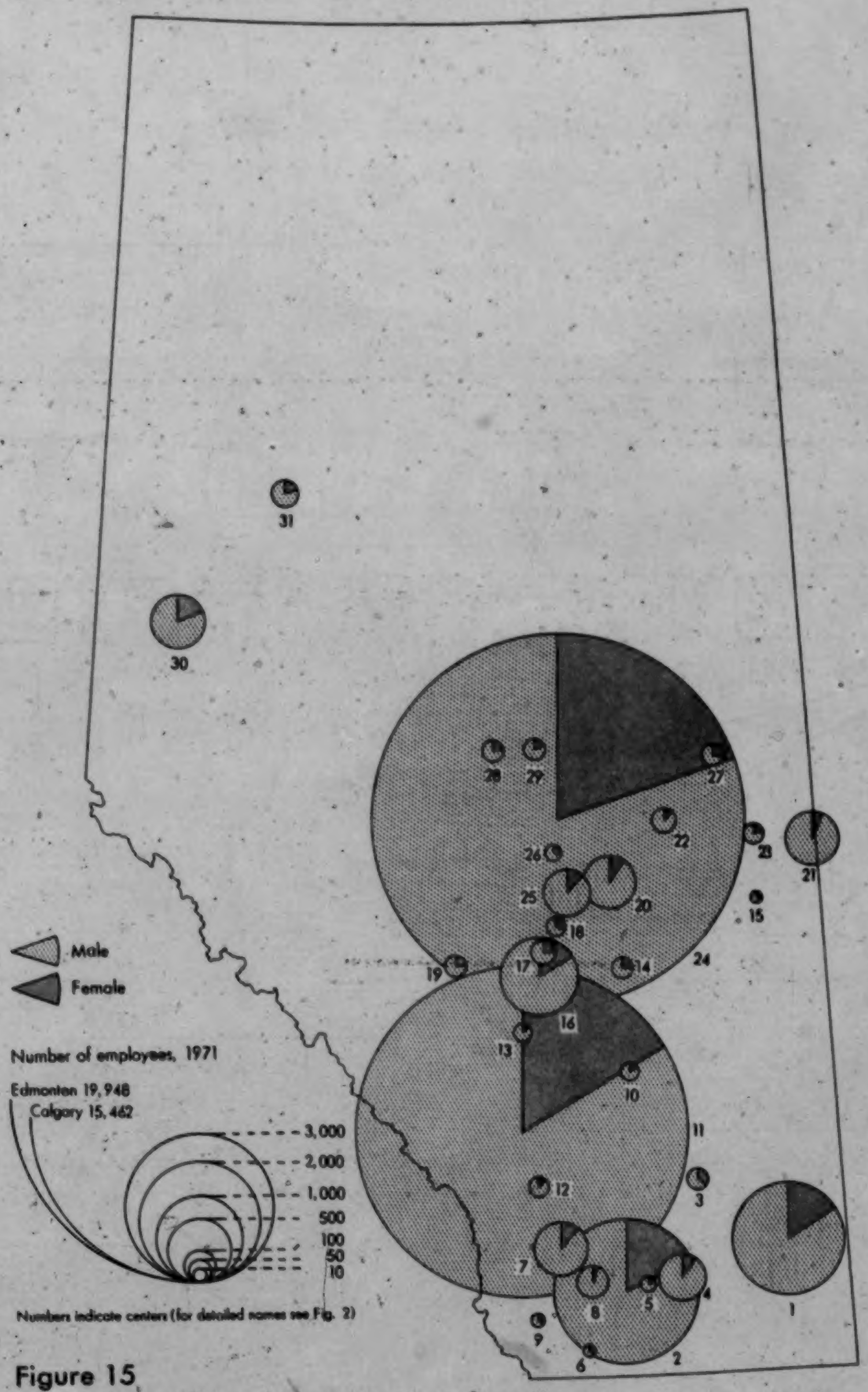


Figure 15
Distribution of Employees in Manufacturing (per center)

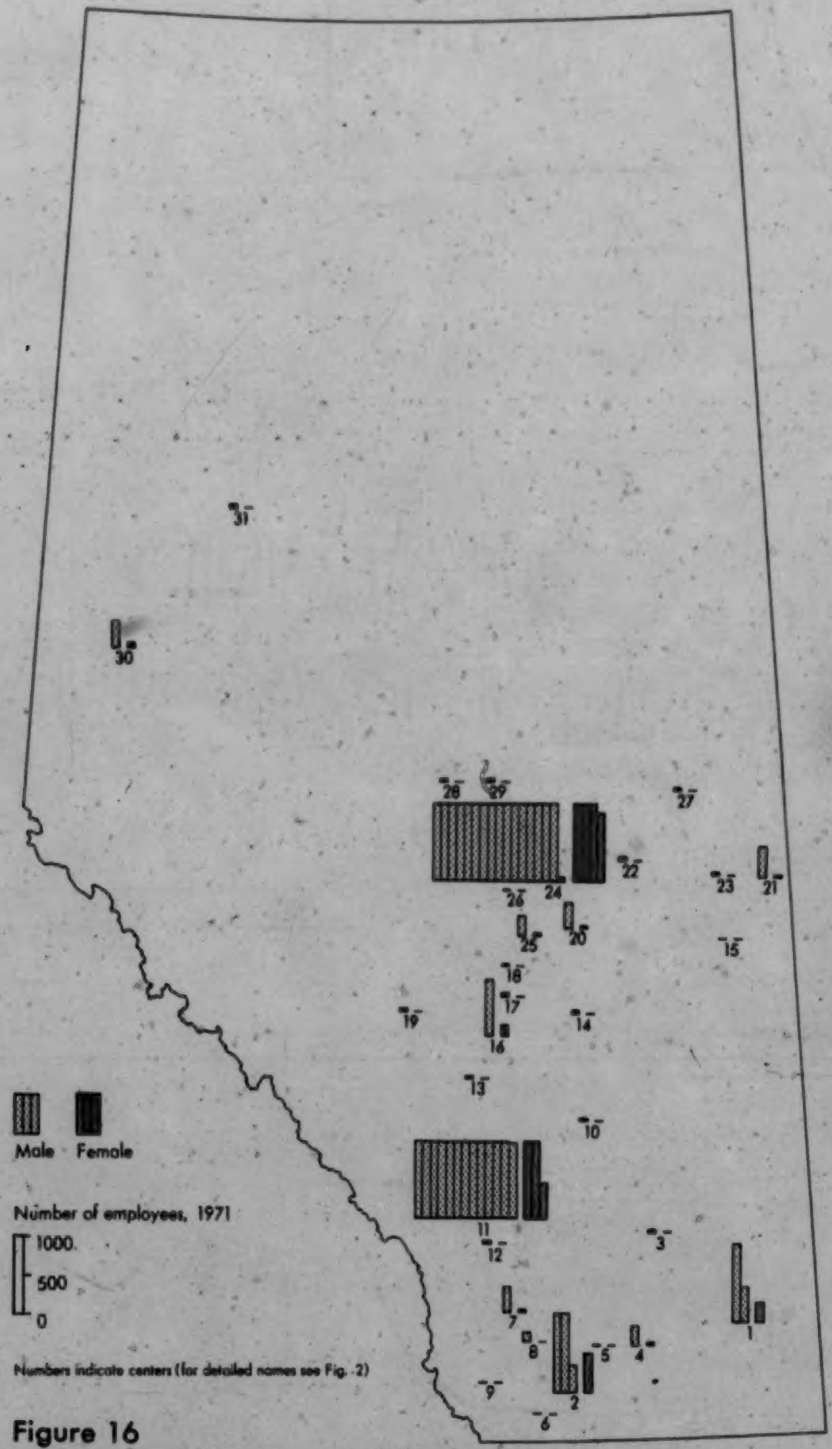
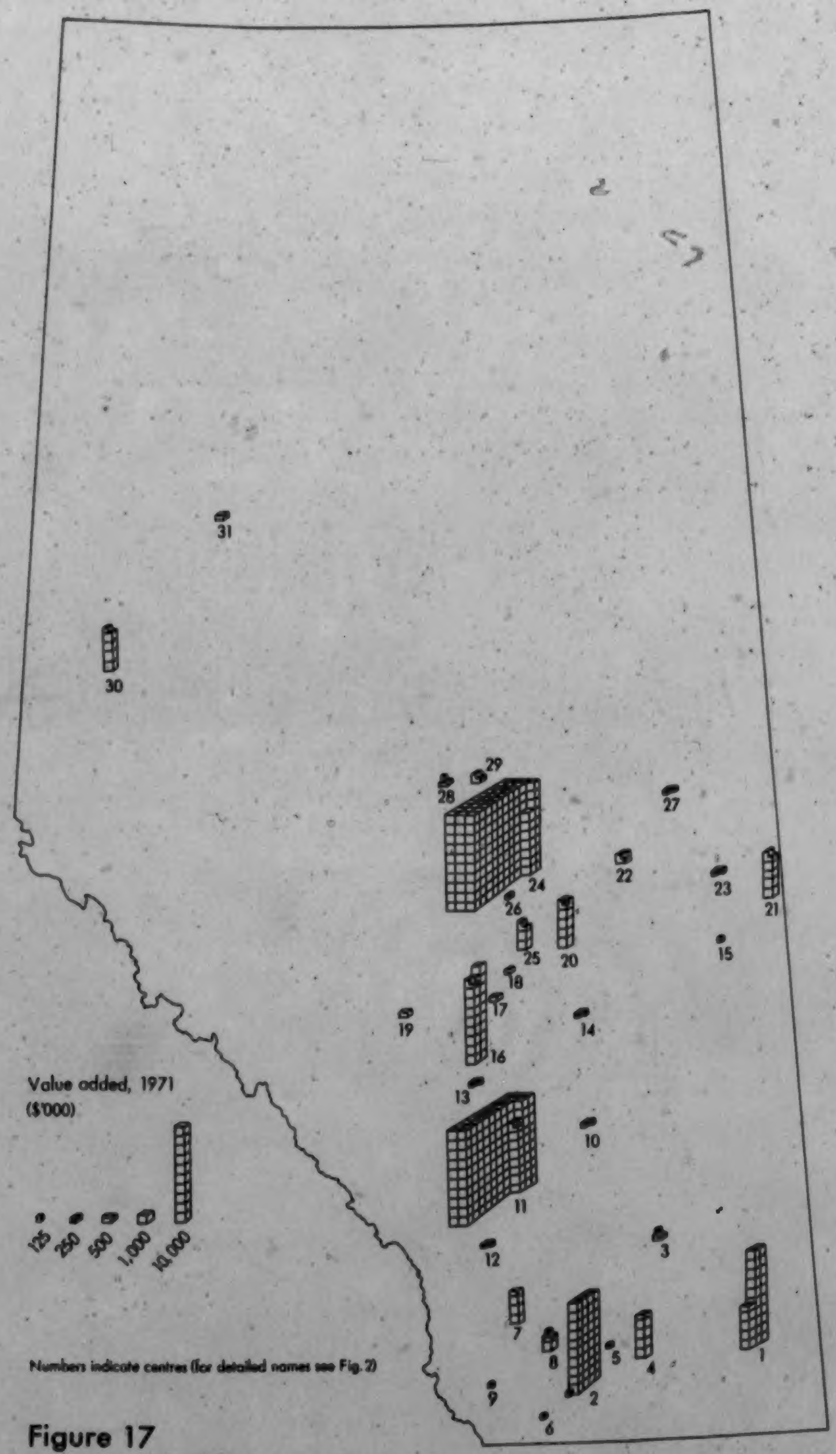

31
30
28
29
27
24
22
23
21
26
20
25
15
18
17
19
16
14
13
10
Male
Female
11
Number of employees, 1971
1000
500
0
12
3
7
1
8
5
4
2
9
6
Numbers indicate centers (for detailed names see Fig. 2)

Figure 16
Distribution of Employees in Manufacturing (per center)



Numbers indicate centres (for detailed names see Fig. 2)

Figure 17
Value Added by Manufacturing
(per center)

CANADIAN THESES
ON MICROFICHE

29495

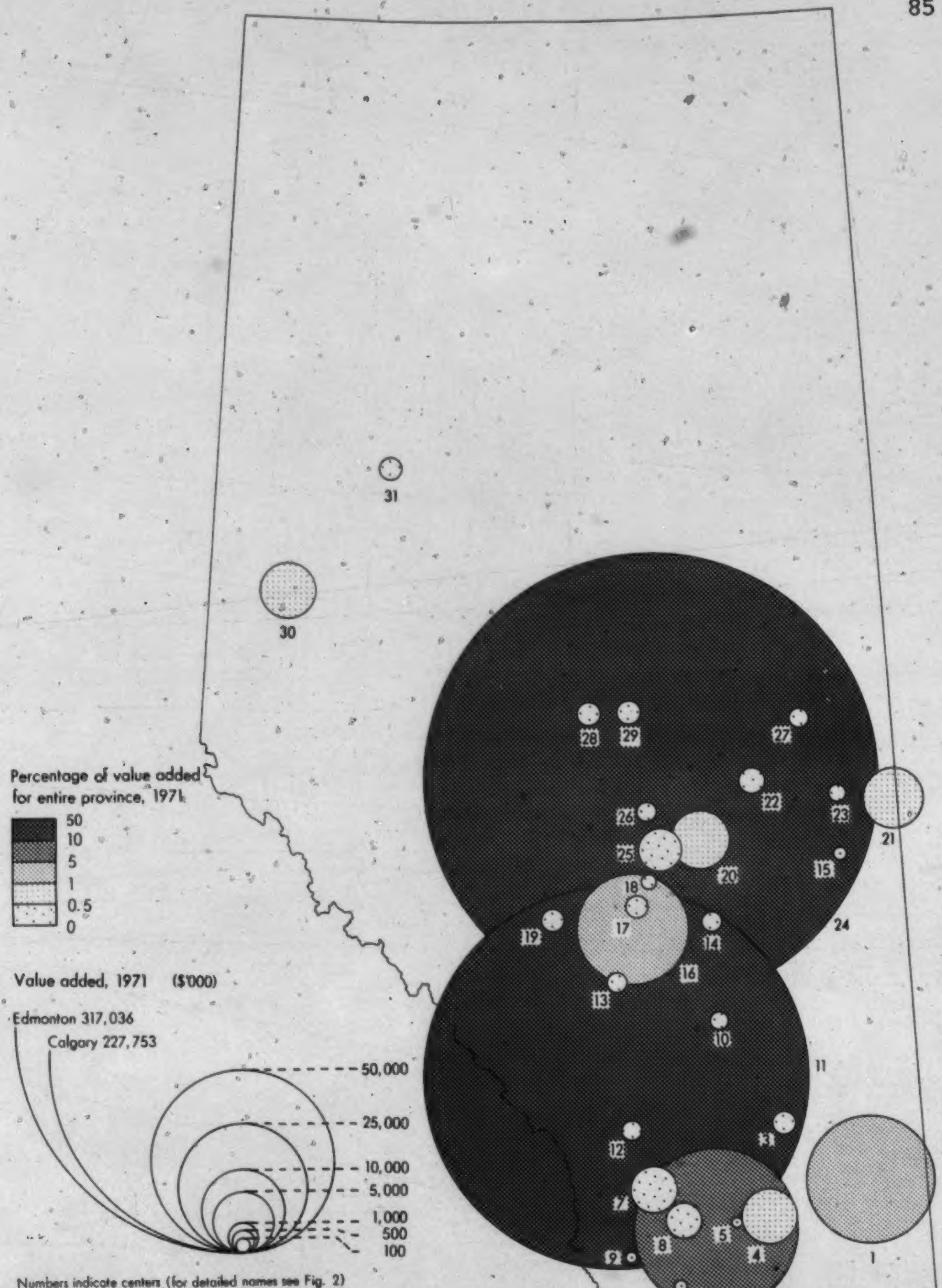
THÈSES CANADIENNES
SUR MICROFICHE

AUTHOR/AUTEUR

CHONG, S.-F.

TITLE/TITRE

SOME ASPECTS OF INDUSTRIAL
MAPPING.



Numbers indicate centers (for detailed names see Fig. 2)

Figure 18
Value Added by Manufacturing (per center)

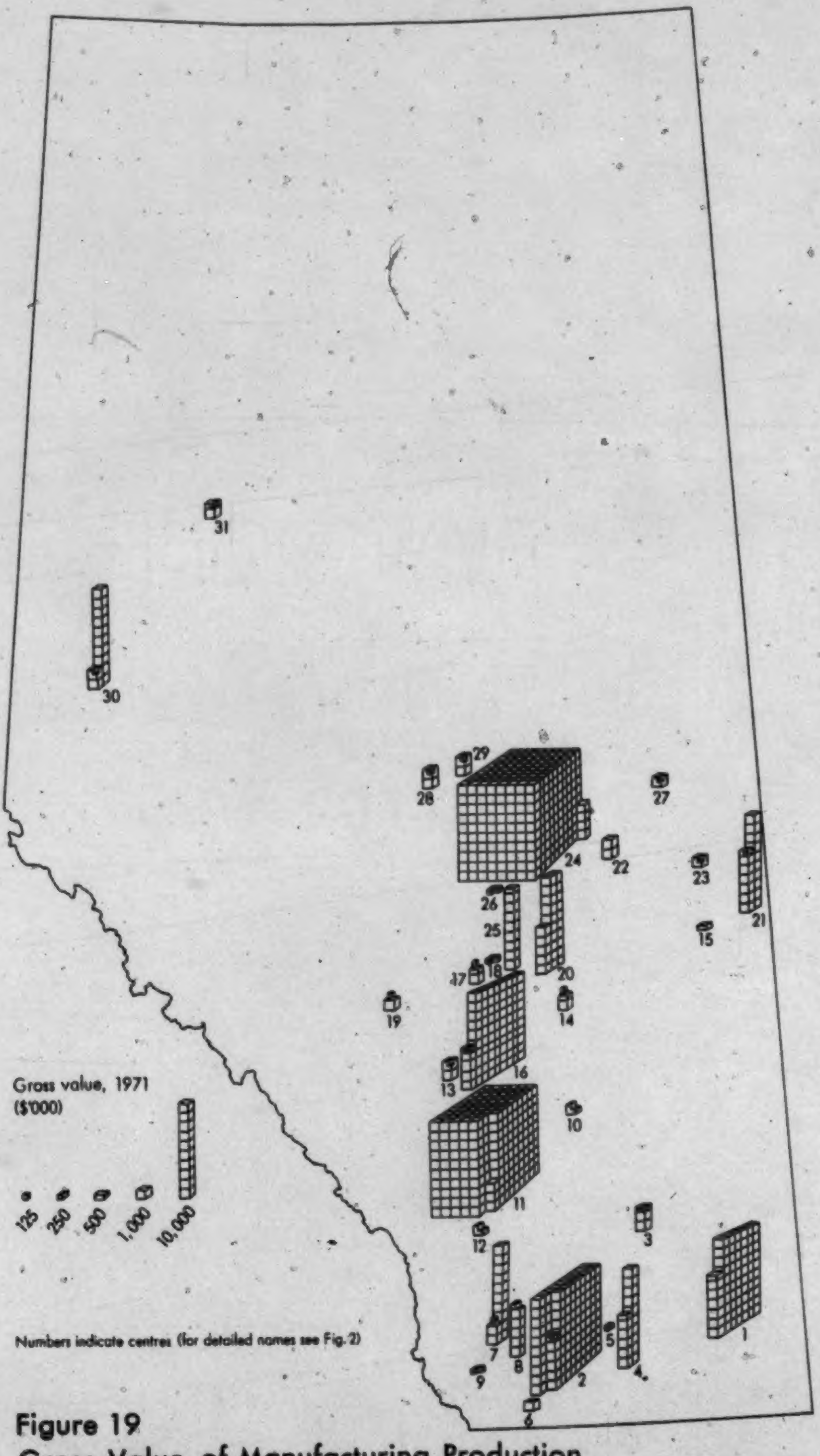


Figure 19
Gross Value of Manufacturing Production (per center)

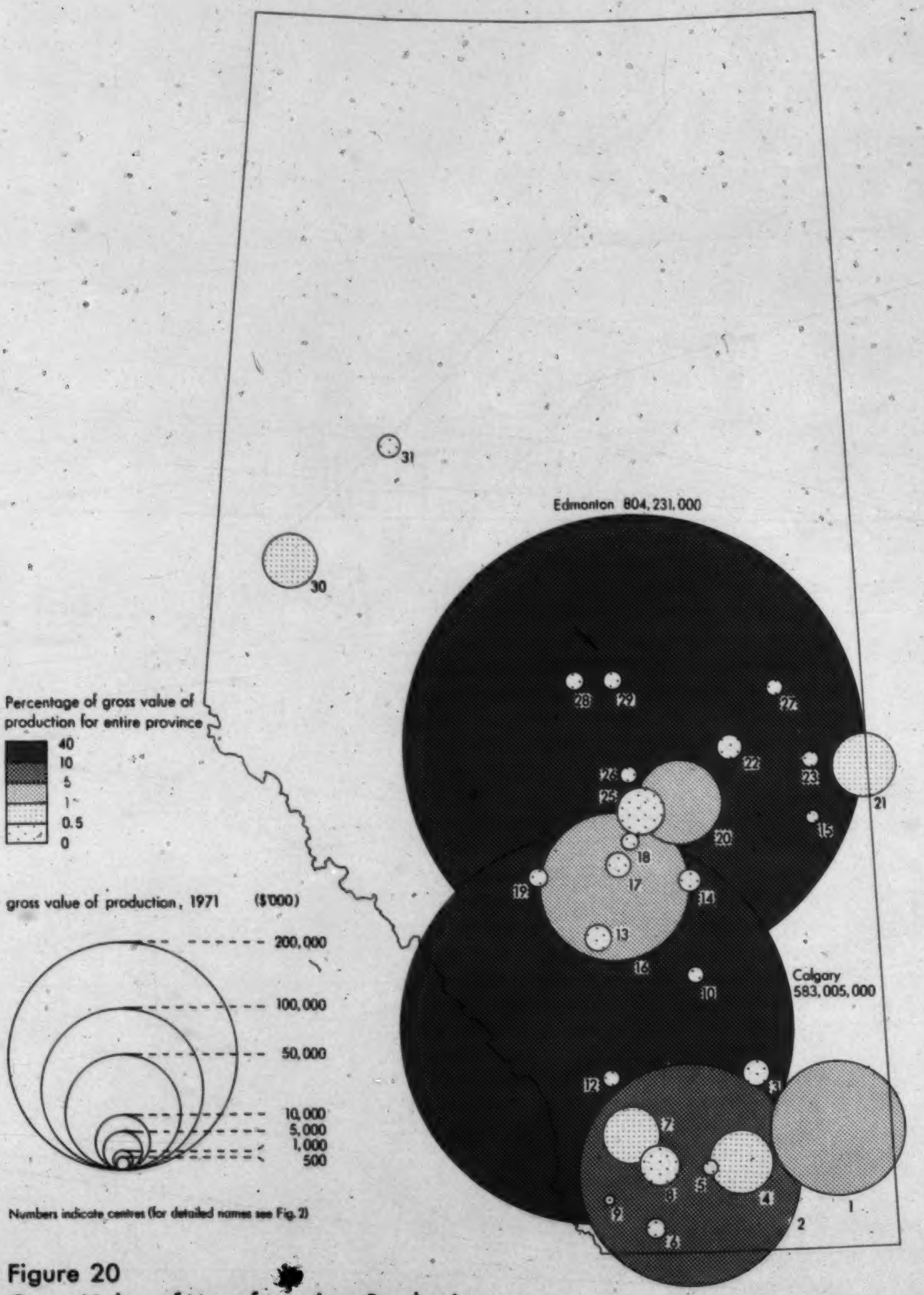
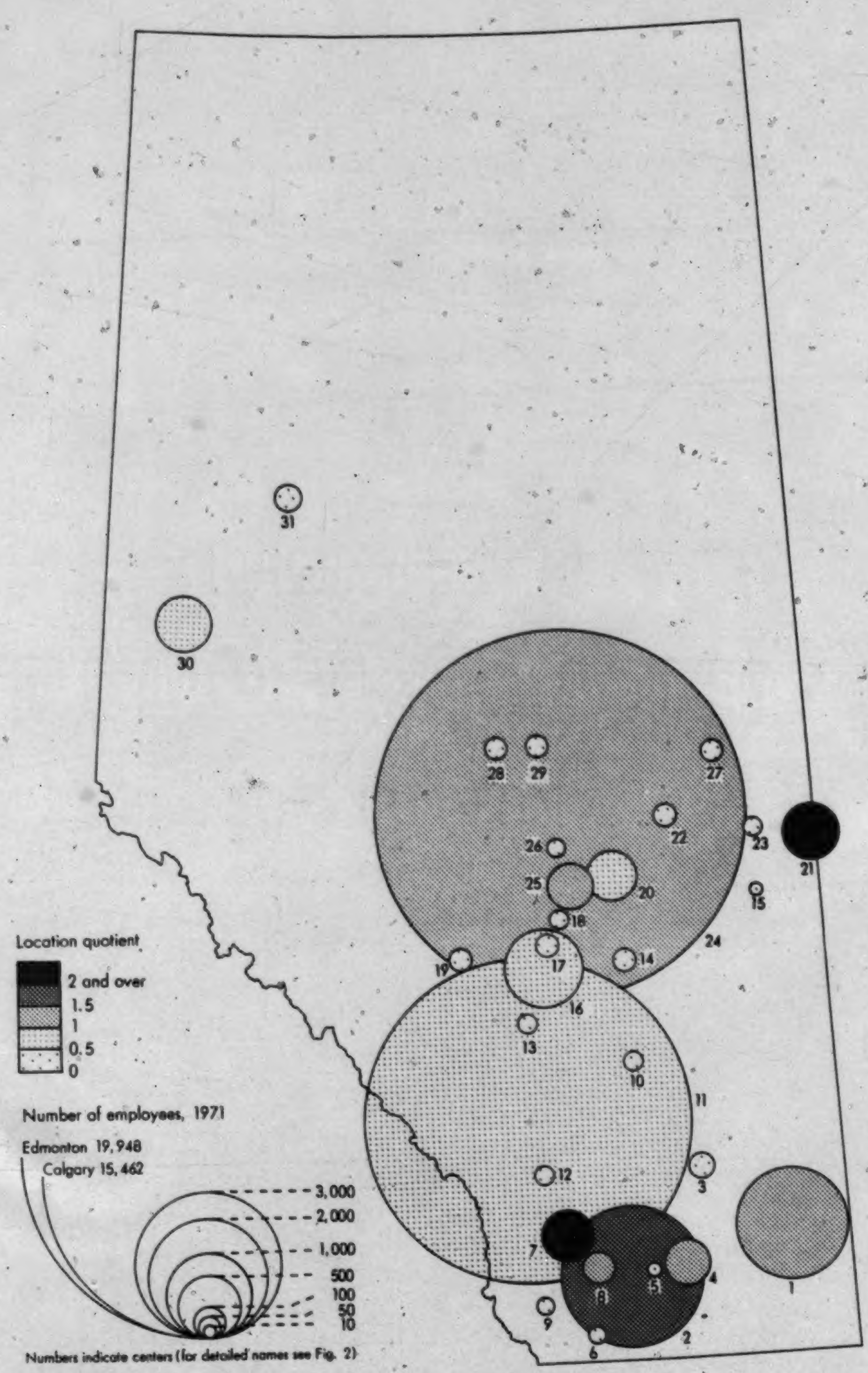

Edmonton 804,231,000
Calgary
583,005,000
Percentage of gross value of production for entire province
40
10
5
1
0.5
0
gross value of production, 1971 ($000)
200,000
100,000
50,000
10,000
5,000
1,000
500
Numbers indicate centres (for detailed names see Fig. 2)
1
2
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
25
26
27
28
29
30
31

Figure 20
Gross Value of Manufacturing Production (per census division)



Numbers indicate centers (for detailed names see Fig. 2)

Figure 21
Location Quotient of Employees in Manufacturing (per center)

CHAPTER V

SUMMARY AND CONCLUSIONS

To construct maps depicting manufacturing information, the cartographer should first thoroughly understand the basic problems involved; for example, map projection, map scale, generalization and symbolization of data. The study area could be distorted through the poor choice of a map projection. Furthermore, the details of information and symbol size or pattern intensity to be presented have to be in harmony with the map scale. A good knowledge of the basic design on the part of the cartographer will lead to a better understanding by the reader of the manufacturing information portrayed in the map.

There is a striking diversity of cartographic techniques for mapping manufacturing data. For a single set of data, maps of quite different appearance can be made. At the same time, due to the varying character of manufacturing data, the cartographer must carefully select different methods to represent different sets of data, so as to stress the peculiar characteristics of the data involved.

Despite the diversity of techniques available, it is obvious that there is very little research actually being done on manufacturing mapping. In the studies which are available, there is usually only a map using one or two cartographic methods. None of these studies actually evaluates the different cartographic methods for their suitability to portray particular categories of manufacturing information. Just as some of the methods may be more suitable for showing statistics with a small range, others may be more suitable for portraying statistics of large range. Differences in the choice of methods applied will therefore result in different degrees of refinement on the map.

The study presented here uses different catographic methods to represent the same categories of manufacturing statistics, in order to determine which particular method is most suitable in each case. The evaluation of each method is based upon logical considerations of the inherent capacity of that method to show the information in the clearest manner.

In the Province of Alberta, manufacturing activities in each census division possess important characteristics of their own. The degree of contrast in their economic impact is especially significant. Manufacturing industry tends to be concentrated in census divisions 6 and 11, where Calgary and Edmonton are located. Comparatively speaking, manufacturing activity in other divisions is considerably less important. To portray this extreme distributional range on distribution maps, the methods used have to be carefully chosen. For example, repeated symbols are most suitable to represent small quantities, especially when the range of value is not too great. This is because the repeated symbol method needs relatively more space. This method was found to be the best to use for portraying information on number of establishments.

For information which has a greater range, such as number of employees, repeated symbols are less efficient than other methods. The proportional circle, where the size of the circle is proportional to the number represented, is the most suitable method for indicating the number of employees. By comparing the size of the circles, the map user is able to gain a quick understanding of the concentration of employment.

For those data which have an extremely large range, the cube symbols is more efficient than the proportional circle. In general, the weakness of using three-dimensional cube symbols is that the value is represented according to the volume of the cube, and this is not always realized on visual inspection. Still, it is possible to take advantage of the fact that cube symbols can portray much more value than other symbols, by using cube symbols in an accumulated manner to portray information which has an extremely large range. The accumulated cube device not only can portray statistics much more accurately than the one-cube device. Consequently it can be suggested that this method should be more frequently used to portray information with a great range. For example, in the province of Alberta, the difference between lowest and highest value of value added and gross value of production is very large. The highest values can be nearly two thousand times as great as the lowest values. Besides the accumulated cube symbol, there is no other method which can efficiently and accurately portray this sort of quantitative information in a locational framework.

Generally speaking, the cartographer tries to apply a simple design of graphic symbols, and to maintain a good balance in the cartographic layout as a whole, in order to create an aesthetically excellent map; while at the same time enabling the map user to extract quickly the essential patterns of information being portrayed. The kind of technique which the cartographer uses will depend to a large extent on the purpose of the map, although the map scale and the nature of the statistical data available are also important factors. These practical factors, as well as the artistic goal of clear, well-balanced design, must be considered simultaneously in order to produce a functional manufacturing map.

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APPENDIX A

PRELIMINARY PRINCIPAL STATISTICS OF THE MANUFACTURING INDUSTRIES, BY CENSUS DIVISIONS
ALBERTA - 1961

	Establishments	Employees Male	Employees Female	Employees TOTAL	Salaries and Wages	Cost of Fuel and Electricity	Cost of Materials	Value of Production Net	Value of Production Gross
	No.	No.	No.	No.	$	$	$	$	$
DIVISION No. 1									
Medicine Hat	37	1,038	103	1,141	4,566,055	676,220	19,469,622	12,702,820	32,948,662
Other	6	510	230	740	2,821,836	75,415	3,137,974	4,703,840	7,817,229
GRAND TOTAL	43	1,548	333	1,881	7,387,891	751,635	22,607,596	17,406,660	40,765,891
DIVISION No. 2									
Lethbridge	63	1,135	254	1,389	5,120,529	449,526	25,525,346	17,176,073	43,150,945
Brooks	5	30	17	47	130,098	23,755	669,302	211,321	904,278
Other	26	585	75	660	2,330,540	480,519	11,993,250	4,043,163	16,517,032
GRAND TOTAL	94	1,750	346	2,096	7,581,167	953,800	38,187,898	21,430,557	60,572,255
DIVISION No. 3									
Cardston	3	4	-	4	7,639	291	9,950	15,602	25,843
Fort MacLeod	4	11	6	17	48,830	3,211	96,047	63,918	163,176
Pincher Creek	4	11	4	15	46,294	4,137	157,054	90,971	262,163
Other	21	230	66	296	752,382	47,569	2,464,551	1,939,538	4,441,658
GRAND TOTAL	32	256	76	332	853,145	55,208	2,727,602	2,110,029	4,892,839
DIVISION No. 4									
Hanna	5	14	6	20	67,638	5,279	255,838	133,362	394,679
Other	2	2	1	3	6,069	145	4,800	7,805	12,550
GRAND TOTAL	7	16	7	23	73,707	5,424	260,638	141,167	407,229
DIVISION No. 5									
Drumheller	3	23	3	26	78,274	4,236	68,876	129,087	200,179
Linden	5	12	-	12	38,102	2,853	67,274	58,860	128,996
Three Hills	5	24	-	24	79,353	2,476	152,597	136,790	291,883
Vulcan	4	10	3	13	39,200	1,730	63,756	52,701	118,207
Other	8	14	2	16	60,011	6,733	206,374	70,521	283,628
GRAND TOTAL	25	83	8	91	275,940	18,048	558,877	447,948	1,022,873
DIVISION No. 6									
Calgary	360	9,403	1,637	11,040	46,618,956	2,773,378	181,828,180	96,559,006	282,160,752
Olds	5	16	5	21	52,831	7,525	330,616	145,809	488,780
Sundre	5	21	4	25	60,298	6,564	351,601	107,754	463,919
Other	33	121	28	149	534,779	79,550	3,912,712	1,486,540	5,479,802
GRAND TOTAL	403	9,561	1,674	11,235	47,266,864	2,867,227	186,423,898	98,299,109	288,590,334
DIVISION No. 7									
Stettler	10	33	9	42	160,048	10,310	443,150	239,443	693,114
Wainwright	3	10	4	14	44,823	3,898	96,827	81,733	182,368
Other	18	150	21	171	673,588	221,923	3,854,361	2,270,038	6,346,312
GRAND TOTAL	31	193	34	227	878,459	236,131	4,394,347	2,601,196	7,221,874
DIVISION No. 8									
Red Deer	27	293	82	375	1,242,144	130,853	6,104,277	4,057,561	10,292,491
Innisfail	7	44	9	53	202,935	34,150	1,298,494	621,939	1,074,559
Lacombe	5	25	6	31	105,158	8,484	406,227	174,285	587,096
Ponoka	9	36	6	42	119,096	12,073	607,862	224,031	852,966
Rocky Mountain House	5	33	9	42	121,492	13,266	748,442	574,439	1,338,125
Other	68	109	20	129	301,346	59,359	1,963,916	537,216	2,560,691
GRAND TOTAL	121	540	132	672	2,102,171	278,171	11,129,189	6,189,568	17,008,928
DIVISION No. 9									
Banff	4	12	11	23	66,483	4,126	35,780	117,353	217,238
Other	76	357	57	414	1,902,581	853,959	2,804,836	4,092,711	7,811,526
GRAND TOTAL	80	369	68	437	1,969,064	858,085	2,840,616	4,210,063	8,028,764
DIVISION No. 10									
GRAND TOTAL	58	593	58	651	2,501,900	878,017	17,630,850	10,404,878	28,912,765
DIVISION No. 11									
Edmonton	412	12,310	3,033	15,343	65,634,519	6,760,535	248,566,755	154,183,997	409,320,287
Wetaskiwin	11	57	23	80	250,034	12,559	1,853,441	309,769	2,175,768
Morinville	3	6	1	7	18,144	790	27,000	26,639	54,429
Stony Plain	4	6	2	8	18,399	960	45,979	26,731	72,661
Other	42	733	32	765	3,044,641	636,212	14,921,556	10,585,189	25,142,997
GRAND TOTAL	472	13,112	3,091	16,203	68,965,736	7,420,055	265,414,722	165,132,325	437,067,102
DIVISION No. 12									
St. Paul	6	26	10	36	100,120	9,337	584,870	181,878	776,085
Other	27	61	14	75	182,241	30,206	1,307,394	295,165	1,632,765
GRAND TOTAL	33	87	24	111	282,361	39,543	1,892,264	477,043	2,408,850
DIVISION No. 13									
Athabasca	5	48	9	57	112,469	8,568	500,391	320,740	829,699
Onoway	3	45	3	48	96,017	24,607	362,454	12,524	399,585
Other	73	211	19	230	636,722	56,418	3,867,109	898,431	4,821,958
GRAND TOTAL	81	304	31	335	845,208	89,593	4,729,954	1,231,695	6,051,242
DIVISION No. 14									
Edson	3	28	9	37	87,113	4,363	161,754	53,959	220,076
Other	51	661	33	694	3,412,059	1,251,848	12,126,130	12,456,238	25,834,216
GRAND TOTAL	54	689	42	731	3,499,172	1,256,211	12,287,884	12,510,197	26,054,292
DIVISION No. 15									
Grande Prairie	19	382	61	443	1,485,042	200,960	3,900,315	2,441,103	7,542,377
Peace River	6	25	10	35	106,810	13,594	406,716	252,842	672,152
Other	92	1,020	11	1,031	2,349,698	266,967	6,296,039	5,048,405	10,611,411
GRAND TOTAL	117	1,427	82	1,509	3,941,550	481,521	10,603,070	7,742,349	18,825,940

Source: Alberta Industry and Resources, 1964. The Alberta Bureau of Statistics. Edmonton, Alberta. 1964, p. 31.

APPENDIX B

MANUFACTURING INDUSTRIES - ALBERTA - 1971

(By Census Division; By Major Industry Group)

Census Division No. 1	Estab-lishments No.	Cost of Materials ($'000)	Employees No.	Male	Female	Salaries ($'000)	Value of Shipments of Goods of Own Manufacture ($'000)	Value Added ($'000)
Foods & Beverages	16	27,487	382	325	57	2,399	31,520	3,897
Rubber & Plastic Products	1	x	x	x	x	x	x	x
Wood Industries	1	x	x	x	x	x	x	x
Furniture & Fixture Industries	4	135	10	10	-	46	195	59
Printing, Publishing & Allied Industries	4	132	71	57	14	459	889	748
Metal Fabricating Industries	6	756	88	85	3	521	1,783	1,015
Transportation Equipment	1	x	x	x	x	x	x	x
Non-Metallic Mineral Products	10	x	x	x	x	x	x	x
Chemical & Chemical Products	1	x	x	x	x	x	x	x
Miscellaneous Manufacturing Industries	3	14	5	5	-	51	77	62
Total All Industries	47	41,210	1,708	1,443	265	11,776	66,423	24,472

Census Division No. 2								
Foods & Beverages	50	146,013	1,976	1,668	308	13,390	179,086	31,800
Rubber & Plastic Products	1	x	x	x	x	x	x	x
Textile Industries	1	x	x	x	x	x	x	x
Clothing & Knitting Industries	1	x	x	x	x	x	x	x
Wood Industries	6	414	45	44	1	261	768	345
Furniture & Fixture Industries	9	172	19	17	2	99	298	123
Paper & Allied Industries	1	x	x	x	x	x	x	x
Printing, Publishing & Allied Industries	10	484	179	137	42	179	2,781	2,270
Primary Metal Industry	1	x	x	x	x	x	x	x
Metal Fabricating Industries	8	1,202	94	91	3	683	4,493	3,267
Machinery Industries	8	1,804	203	195	8	1,111	3,653	1,812
Transportation Equipment	5	8,449	525	482	43	2,947	13,738	5,238
Electrical Products	1	x	x	x	x	x	x	x
Non-Metallic Mineral Products	10	x	x	x	x	x	x	x
Chemical & Chemical Products	1	x	x	x	x	x	x	x
Miscellaneous Manufacturing	10	164	45	38	7	299	713	539
Total All Industries	123	165,097	3,481	2,917	564	22,155	216,818	50,175

Census Division No. 3								
Foods & Beverages	14	1,921	60	49	11	305	2,406	458
Textile Industries	1	x	x	x	x	x	x	x
Wood Industries	5	3,964	216	204	12	1,222	6,824	2,787
Printing, Publishing & Allied Industries	6	67	21	14	7	97	206	138
Metal Fabricating Industries	2	x	x	x	x	x	x	x
Transportation Equipment	5	x	x	x	x	x	x	x
Electrical Products	1	x	x	x	x	x	x	x
Non-Metallic Mineral Products	1	x	x	x	x	x	x	x
Total All Industries	35	14,783	671	604	67	3,877	21,895	6,913

Census Division No. 4								
Foods & Beverages	1	x	x	x	x	x	x	x
Printing, Publishing & Allied Industries	2	x	x	x	x	x	x	x
Metal Fabricating Industries	2	x	x	x	x	x	x	x
Total All Industries	5	105	22	18	4	104	288	180

Census Division No. 5								
Foods & Beverages	9	623	25	18	7	127	850	214
Rubber & Plastic Products	1	x	x	x	x	x	x	x
Printing, Publishing & Allied Industries	7	133	25	17	8	109	330	195
Metal Fabricating Industries	2	x	x	x	x	x	x	x
Machinery Industries	1	x	x	x	x	x	x	x
Non-Metallic Mineral Products	2	x	x	x	x	x	x	x
Miscellaneous Manufacturing	1	x	x	x	x	x	x	x
Total All Industries	23	1,217	119	100	19	575	2,289	1,025

MANUFACTURING INDUSTRIES - ALBERTA - 1971

(By Census Division; By Major Industry Group)

Census Division No. 6	Establishments No.	Cost of Materials ($'000)	Employees No.	Male	Female	Salaries ($'000)	Value of Shipments of Goods of Own Manufacture ($'000)	Value Added ($'000)
Foods & Beverages	104	167,739	3,829	3,013	816	28,137	229,348	59,829
Rubber & Plastic Products	16	x	x	x	x	x	x	x
Leather Industries	5	405	62	50	12	321	760	351
Textile Industries	8	x	x	x	x	x	x	x
Clothing & Knitting Industries	11	x	x	x	x	x	x	x
Wood Industries	38	19,325	1,178	1,039	139	8,280	31,586	11,963
Furniture & Fixture Industries	37	3,330	400	317	83	2,531	6,858	3,472
Paper & Allied Industries	10	x	x	x	x	x	x	x
Printing, Publishing & Allied Industries	76	8,174	1,676	1,228	448	12,682	31,022	22,636
Primary Metal Industry	12	x	x	x	x	x	x	x
Metal Fabricating Industries	80	26,614	2,548	2,363	185	20,696	63,052	36,010
Machinery Industries	12	6,353	390	370	20	3,160	10,625	4,124
Transportation Equipment	26	15,457	1,162	1,035	127	7,820	26,298	10,652
Electrical Products	9	6,971	257	201	56	1,825	12,459	5,351
Non-Metallic Mineral Products	23	10,994	643	629	14	5,423	25,638	14,221
Petroleum & Coal Products	5	x	x	x	x	x	x	x
Chemical & Chemical Products	17	10,957	708	666	42	6,324	28,459	16,165
Miscellaneous Manufacturing	66	3,508	487	365	122	3,090	8,105	4,511
Total All Industries	555	352,524	15,678	13,181	2,497	118,064	589,716	230,228

Census Division No. 7	Establishments No.	Cost of Materials ($'000)	Employees No.	Male	Female	Salaries ($'000)	Value of Shipments of Goods of Own Manufacture ($'000)	Value Added ($'000)
Foods & Beverages	19	2,710	98	80	18	547	3,726	961
Furniture & Fixture Industries	3	x	x	x	x	x	x	x
Printing, Publishing & Allied Industries	5	100	30	20	10	152	312	210
Metal Fabricating Industries	1	x	x	x	x	x	x	x
Transportation Equipment	1	x	x	x	x	x	x	x
Non-Metallic Mineral Products	2	x	x	x	x	x	x	x
Total All Industries	31	3,066	140	112	28	747	4,475	1,344

Census Division No. 8	Establishments No.	Cost of Materials ($'000)	Employees No.	Male	Female	Salaries ($'000)	Value of Shipments of Goods of Own Manufacture ($'000)	Value Added ($'000)
Foods & Beverages	43	61,475	523	454	69	3,696	70,966	9,185
Wood Industries	9	636	73	69	4	419	1,439	774
Furniture & Fixture Industries	2	x	x	x	x	x	x	x
Printing, Publishing & Allied Industries	14	557	145	109	36	878	2,199	1,630
Metal Fabricating Industries	6	x	x	x	x	x	x	x
Machinery Industries	2	x	x	x	x	x	x	x
Transportation Equipment	1	x	x	x	x	x	x	x
Electrical Products	1	x	x	x	x	x	x	x
Non-Metallic Mineral Products	4	x	x	x	x	x	x	x
Petroleum & Coal Products	1	x	x	x	x	x	x	x
Miscellaneous Manufacturing	5	65	19	12	7	109	209	142
Total All Industries	88	75,575	1,188	995	193	7,605	99,798	23,654

Census Division No. 9	Establishments No.	Cost of Materials ($'000)	Employees No.	Male	Female	Salaries ($'000)	Value of Shipments of Goods of Own Manufacture ($'000)	Value Added ($'000)
Foods & Beverages	4	310	30	17	13	186	569	242
Wood Industries	31	x	x	x	x	x	x	x
Furniture & Fixture Industries	1	x	x	x	x	x	x	x
Printing, Publishing & Allied Industries	4	78	21	14	7	114	288	209
Electrical Products	1	x	x	x	x	x	x	x
Non-Metallic Mineral Products	5	x	x	x	x	x	x	x
Total All Industries	46	7,050	757	704	53	5,245	21,565	13,132

Census Division No. 10	Establishments No.	Cost of Materials ($'000)	Employees No.	Male	Female	Salaries ($'000)	Value of Shipments of Goods of Own Manufacture ($'000)	Value Added ($'000)
Foods & Beverages	36	5,922	227	180	47	1,160	8,450	2,383
Wood Industries	1	x	x	x	x	x	x	x
Furniture & Fixture Industries	2	x	x	x	x	x	x	x
Paper & Allied Industries	1	x	x	x	x	x	x	x
Printing, Publishing & Allied Industries	9	301	79	54	25	461	960	660
Primary Metal Industry	1	x	x	x	x	x	x	x
Metal Fabricating Industries	6	1,151	77	73	4	610	1,985	797
Machinery Industries	2	x	x	x	x	x	x	x
Non-Metallic Mineral Products	6	434	40	38	2	217	832	355
Petroleum & Coal Products	2	x	x	x	x	x	x	x
Chemical & Chemical Products	1	x	x	x	x	x	x	x
Miscellaneous Manufacturing	1	x	x	x	x	x	x	x
Total All Industries	68	36,433	1,016	921	95	7,193	49,670	12,288

MANUFACTURING INDUSTRIES - ALBERTA - 1971

(By Census Division; By Major Industry Group)

Census Division No. 11	Establishments No.	Cost of Materials ($'000)	Employees No.	Male	Female	Salaries ($'000)	Value of Shipments of Goods of Own Manufacture ($'000)	Value Added ($'000)
Foods & Beverages	116	216,827	6,044	5,074	970	44,632	299,789	80,836
Rubber & Plastic Products	17	x	x	x	x	x	x	x
Leather Industries	5	x	x	x	x	x	x	x
Textile Industries	13	x	x	x	x	x	x	x
Clothing & Knitting Industries	14	13,506	1,622	342	1,280	8,280	31,162	17,560
Wood Industries	46	14,488	1,054	955	99	6,379	25,377	10,621
Furniture & Fixture Industries	46	5,309	757	614	143	4,208	11,852	6,450
Paper & Allied Industries	8	x	x	x	x	x	x	x
Printing, Publishing & Allied Industries	65	7,486	1,311	917	394	8,980	26,531	18,931
Primary Metal Industry	9	x	x	x	x	x	x	x
Metal Fabricating Industries	120	25,341	2,422	2,212	210	17,089	55,620	29,799
Machinery Industries	18	11,780	753	706	47	7,179	20,467	8,464
Transportation Equipment	25	7,766	816	732	84	5,382	17,461	9,549
Electrical Products	6	1,389	106	74	32	593	2,273	870
Non-Metallic Mineral Products	33	20,348	1,362	1,275	87	11,924	62,705	40,562
Petroleum & Coal Products	7	108,175	691	660	31	7,342	142,343	32,475
Chemical & Chemical Products	24	x	x	x	x	x	x	x
Miscellaneous Manufacturing	70	2,581	531	410	121	3,348	7,145	4,480
Total All Industries	642	522,726	21,594	17,557	4,037	162,084	876,773	338,821

Census Division No. 12	Establishments No.	Cost of Materials ($'000)	Employees No.	Male	Female	Salaries ($'000)	Value of Shipments of Goods of Own Manufacture ($'000)	Value Added ($'000)
Foods & Beverages	15	1,173	91	64	27	435	1,858	638
Wood Industries	15	1,620	154	153	1	898	2,604	902
Furniture & Fixture Industries	2	x	x	x	x	x	x	x
Printing, Publishing & Allied Industries	2	x	x	x	x	x	x	x
Non-Metallic Mineral Products	2	x	x	x	x	x	x	x
Total All Industries	36	3,081	272	240	32	1,481	4,093	1,774

Census Division No. 13	Establishments No.	Cost of Materials ($'000)	Employees No.	Male	Female	Salaries ($'000)	Value of Shipments of Goods of Own Manufacture ($'000)	Value Added ($'000)
Foods & Beverages	14	x	x	x	x	x	x	x
Wood Industries	9	846	81	80	1	467	1,369	482
Printing, Publishing & Allied Industries	4	74	23	16	7	109	246	170
Metal Fabricating Industries	3	x	x	x	x	x	x	x
Transportation Equipment	1	x	x	x	x	x	x	x
Non-Metallic Mineral Products	4	323	25	24	1	148	943	598
Chemical & Chemical Products	1	x	x	x	x	x	x	x
Total All Industries	36	16,459	471	431	40	3,684	27,660	9,116

Census Division No. 14	Establishments No.	Cost of Materials ($'000)	Employees No.	Male	Female	Salaries ($'000)	Value of Shipments of Goods of Own Manufacture ($'000)	Value Added ($'000)
Foods & Beverages	4	x	x	x	x	x	x	x
Rubber & Plastic Products	1	x	x	x	x	x	x	x
Wood Industries	18	x	x	x	x	x	x	x
Paper & Allied Industries	1	x	x	x	x	x	x	x
Printing, Publishing & Allied Industries	3	x	x	x	x	x	x	x
Non-Metallic Mineral Products	2	x	x	x	x	x	x	x
Total All Industries	29	15,740	701	663	38	5,607	31,163	14,043

Census Division No. 15	Establishments No.	Cost of Materials ($'000)	Employees No.	Male	Female	Salaries ($'000)	Value of Shipments of Goods of Own Manufacture ($'000)	Value Added ($'000)
Foods & Beverages	18	3,121	196	151	45	1,153	5,114	1,860
Wood Industries	181	22,657	1,967	1,923	44	11,714	36,226	12,579
Furniture & Fixture Industries	2	x	x	x	x	x	x	x
Printing, Publishing & Allied Industries	8	240	64	37	27	309	716	470
Metal Fabricating Industries	2	x	x	x	x	x	x	x
Transportation Equipment	2	x	x	x	x	x	x	x
Non-Metallic Mineral Products	4	646	17	17	-	112	816	149
Miscellaneous Manufacturing	2	x	x	x	x	x	x	x
Total All Industries	219	27,152	2,297	2,175	122	13,603	45,704	15,392 ~~45,704~~
GRAND TOTAL ALLL INDUSTRIES	1,983	1,282,217	50,115	42,061	8,054	363,800	2,057,232	742,558

x Figures confidential and witheld

Source: Alberta Bureau of Statistics

APPENDIX C

PRELIMINARY PRINCIPAL STATISTICS - MANUFACTURING INDUSTRIES

BY CENSUS DIVISIONS - ALBERTA - 1971

	Estab-lishments No.	Employees Male No.	Employees Female No.	Employees Total No.	Salaries & Wages $'000	Cost of Fuel & Electricity $'000	Cost of Materials $'000	Value Added $'000	Value of Shipment of Goods of Own Manufacture $'000
Division No. 1									
Medicine Hat & Redcliff	47	1,443	265	1,708	11,776	741	41,210	24,472	66,423
Total	47	1,443	265	1,708	11,776	741	41,210	24,472	66,423
Division No. 2									
Lethbridge	82	2,334	499	2,833	18,219	973	144,094	40,236	185,304
Brooks	11	36	19	55	284	22	1,638	636	2,296
Taber	10	257	29	286	1,860	302	10,740	4,515	15,558
Vauxhall	3	22	-	22	117	36	493	333	861
Coaldale	4	12	3	15	68	7	453	119	578
Other Municipalities	13	256	14	270	1,607	206	7,680	4,336	12,221
Total	123	2,917	564	3,481	22,155	1,546	165,097	50,175	216,818
Division No. 3									
Cardston	5	12	6	18	90	7	767	178	952
Claresholm	11	318	39	357	2,141	94	8,739	3,293	12,126
Fort MacLeod	6	122	4	126	777	69	3,519	1,640	5,228
Pincher Creek	4	13	5	18	79	5	188	104	297
Other Municipalities	9	139	13	152	790	24	1,570	1,698	3,292
Total	35	604	67	671	3,877	199	14,783	6,913	21,895
Division No. 4									
All Municipalities	5	18	4	22	104	3	105	180	288
Division No. 5									
Drumheller	6	32	6	38	197	10	385	376	771
Three Hills	4	7	3	10	43	2	78	59	139
Vulcan	4	9	5	14	72	4	270	124	398
Linden	4	35	-	35	166	12	319	342	673
Other Municipalities	5	17	5	22	97	19	165	124	308
Total	23	100	19	119	575	47	1,217	1,025	2,289

	Estab-lishments No.	Employees Male No.	Employees Female No.	Employees Total No.	Salaries & Wages $'000	Cost of Fuel & Electricity $'000	Cost of Materials $'000	Value. Added $'000	Value of Shipment of Goods of Own Manufacture $'000
Division No. 6									
Calgary	519	12,991	2,471	15,462	116,778	6,851	348,401	227,753	583,005
Didsbury	4	9	1	10	43	3	116	105	224
High River	5	35	5	40	239	5	431	342	778
Okotoks	3	15	10	25	91	9	280	234	523
Olds	5	33	4	37	204	27	1,376	429	1,832
Other Municipalities	19	98	6	104	709	69	1,920	1,365	3,354
Total	555	13,181	2,497	15,678	118,064	6,964	352,524	230,228	589,716
Division No. 7									
Provost	5	17	4	21	107	5	340	148	493
Stettler	9	41	13	54	287	24	1 156	435	1,615
Wainwright	4	12	4	16	79	4	252	152	408
Other Municipalities	13	42	7	49	274	33	1,318	608	1,959
Total	31	112	28	140	747	66	3,066	1,343	4,475
Division No. 8									
Red Deer	36	724	137	861	5,588	389	65,150	18,821	84,360
Lacombe	9	53	17	70	384	25	1,035	586	1,646
Ponoka	9	26	11	37	197	14	440	278	732
Rimbey	6	16	5	21	106	6	499	119	624
Rocky Mountain House	5	38	11	49	244	29	535	588	1,152
Sylvan Lake	3	3	3	6	27	1	56	37	94
Other Municipalities	20	135	9	144	1,059	105	7,860	3,226	11,191
Total	88	995	193	1,188	7,605	569	75,575	23,655	99,799
Division No. 9									
All Municipalities	46	704	53	757	5,245	1,383	7,050	13,132	21,565
Division No. 10									
Camrose	16	318	33	351	2,284	199	20,099	4,796	25,094
Lloydminster	14	390	26	416	3,522	392	11,171	4,751	16,314
Vegreville	5	57	7	64	370	20	1,086	860	1,966
Vermilion	5	35	9	44	232	18	460	402	880
Other Municipalities	28	121	20	141	785	321	3,616	1,479	5,416
Total	68	921	95	1,016	7,193	950	36,432	12,288	49,670

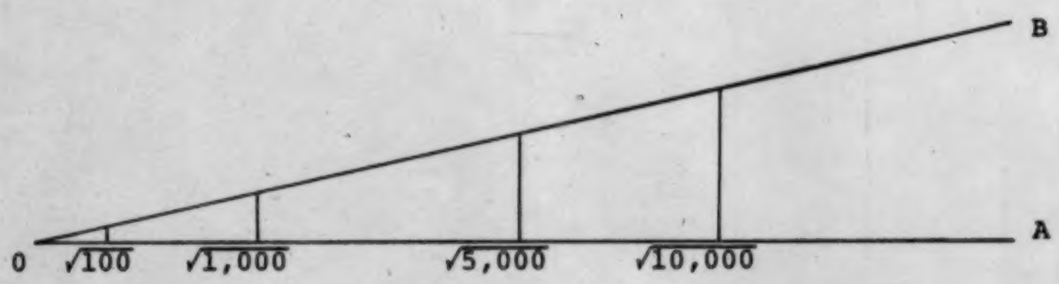
	Estab-lishments No.	Employees			Salaries & Wages $'000	Cost of Fuel & Electricity $'000	Cost of Materials $'000	Value Added $'000	Value of Shipment of Goods of Own Manufacture $'000
		Male No.	Female No.	Total No.					
Division No. 11									
Edmonton	592	16,063	3,885	19,948	148,390	11,489	475,706	317,036	804,231
Wetaskiwin	14	257	33	290	1,571	91	5,635	2,704	8,430
Leduc	5	22	8	30	175	9	320	329	658
Stony Plain	5	15	5	20	119	7	340	202	549
Other Municipalities	26	1,200	106	1,306	11,829	3,630	40,725	18,550	62,905
Total	642	17,557	4,037	21,594	162,084	15,226	522,726	338,821	876,773
Division No. 12									
St. Paul	6	33	13	46	239	17	464	382	863
Other Municipalities	30	207	19	226	1,242	121	2,617	1,392	4,130
Total	36	240	32	272	1,481	138	3,081	1,774	4,993
Division No. 13									
Barrhead	6	38	10	48	278	27	1,173	597	1,797
Westlock	8	40	9	49	256	18	1,164	616	1,798
Other Municipalities	22	353	21	374	3,150	2,040	14,122	7,903	24,065
Total	36	431	40	471	3,684	2,085	16,459	9,116	27,660
Division No. 14									
All Municipalities	29	663	38	701	5,607	1,381	15,740	14,042	31,163
Division No. 15									
Grande Prairie	17	336	78	414	2,729	165	7,367	4,306	11,833
Fairview	3	7	3	10	50	2	63	69	134
Grimshaw	3	4	-	4	16	2	39	37	78
Peace River	8	66	17	83	434	19	855	472	1,346
Valleyview	3	4	-	4	19	1	36	30	67
Other Municipalities	185	1,758	24	1,782	10,355	971	18,792	10,478	30,241
Total	219	2,175	122	2,297	13,603	1,160	27,152	15,392	43,704
Total All Industries	1,983	42,061	8,054	50,115	363,800	32,458	1,282,217	742,556	2,057,231

Source: Alberta Bureau of Statistics

APPENDIX D

Construction of Proportional Circles

(1) Procedure of constructing scale for proportional circles

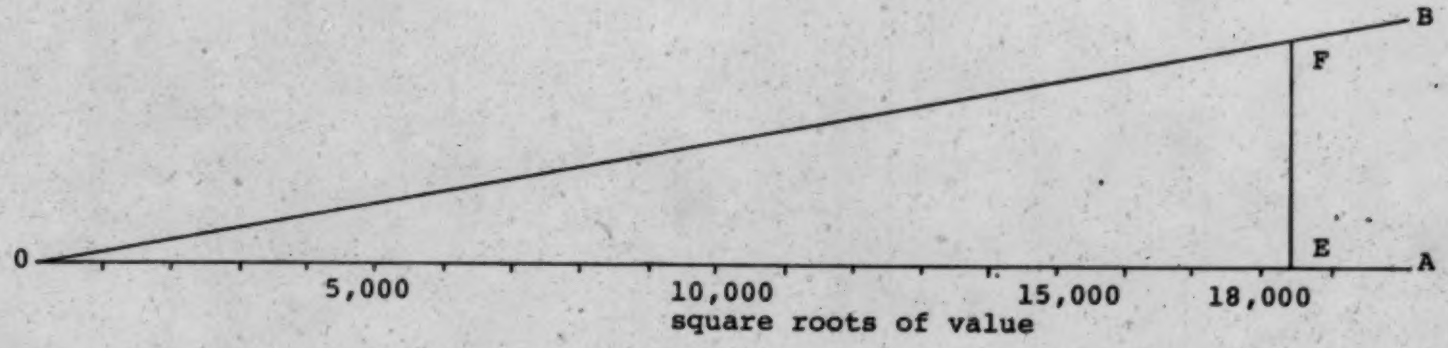


OA - base line, the divisions of which are spaced at distances proportional to the square roots of the values represented.

AOB - angle depends on how large the maximum symbol is to be.

EF - radius of circle represents the number whose square root is indicated at that point.

(2) Radii of circles used to represent value added in Alberta census divisions.



Example (census division 11):

Value added = \$338,821,000 = 338,821,000 = πr^2

$r = \sqrt{338{,}821{,}000}$ (since π is constant)

$OE = \dfrac{\sqrt{338{,}821{,}000}}{100}$ mm

EF = radius of largest circle representing total value added in census division 11.

AOB = 10°

Radii of circles representing total value added in other census divisions can then be measured directly at specific points along OA, according to the square root of the value added.

(3) The procedure of constructing scale for radii of circles to represent value added (in centers), gross value of production (in centers), and number of employees (in census divisions and centers) is the same, only using different angles:

Value added	
in centers	20°
Gross Value of Production	
in centers	20°
Number of employees	
in census division	15°
in centers	20°